Africa-Europe BioClimatic buildings for XXI century

REPORT ON THE REGULATORY AND TRAINING INFRASTRUCTURE IN NORTH-WEST AFRICA & EUROPE

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ABC 21 Project

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Executive Summary

In the framework of the H2020 funded project ABC 21 Africa-Europe BioClimatic buildings for the XXI century, this report intends to shed light on the current regulatory infrastructure on energy efficiency in buildings in the EU, North and West Africa regions. The choice of countries was made in such a way as to have representative countries of each of these three regions. They are Germany, Spain, Portugal, France, Italy, Austria, Morocco, Tunisia, Egypt, Libya, Algeria, Ghana, Togo, Senegal, and Nigeria.

The goal is to identify and analyse the degree of development of these infrastructures, the obstacles encountered, and propose recommendations.

This report has relied on quantitative and qualitative data collection methods to help inform the benchmark and analysis. Methods used during the report elaboration included questionnaires, focused group discussions, interview with key informants and review of existing documents from relevant agencies and other public institutions.

The structure of this report is divided into two chapters, each with three main parts. The first part is the general introduction which specifies the scope, objectives, the structure of the report and work methodology adopted in the development of this study. The second part breaks down the results of all the researched regulatory measures and training programs dealing with buildings in each of the countries included in this study. Finally, an overall analysis of the state of regulations and training related to energy efficiency in buildings in the three regions studied is explained.

The undertaken research has shown significant differences in the development of regulation related to EE in buildings between the European Union, North Africa and West Africa. National regulation at the European Union level stems from the European directives, and constitute an encouraging framework for bioclimatic buildings, despite the fact that most of the existing building codes do not take into account future climatic conditions. However, regular updates are being performed to include new technological advances and future climatic data. In North Africa, countries succeeded in developing building codes with different application levels, but without considerations for upcoming climatic changes. Even though these codes represent a stride forward toward the development of a bioclimatic building market, their update is not envisaged at the time being. In West Africa, regional building energy efficiency measures are being proposed and developed by ECOWAS, especially given the minimal adoption of energy efficiency at the level of the existing building codes and regulation. More importance is given to the use of renewable energy systems in buildings.

Similarly, to the state of play of regulatory infrastructure, EU public and private actors in education and training succeeded to offer a wide range of programs in EE in buildings and urban planning, including modules covering bioclimatic architecture. However, despite the existence of such programs in North and West Africa, there is still a lack in terms of awareness of the importance of bioclimatic architecture, therefore its presence in training programs is almost absent.

Abbreviations

Term	Name
ADEME	Agency for the Environment and Energy Management of France
ADENE	Energy Agency of Portugal
AEME	Agency for Economy and Energy Control of Senegal
ANME	National Agency for Energy Management of Tunisia
AMEE	AMEE Moroccan Agency for Energy Efficiency
APRUE	National Agency for the promotion and rational use of Energy of Algeria
ASN	Senegalese Association for Normalization
BMWi	Federal Ministry for Economy and Energy in Germany
BMUB	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety in Germany
CEE	Energy saving certificates
CPE	Energy performance contracts
COP	Coefficient of Performance
DIN	German Institute for Standardisation
DTR	Regulatory Technical Documents
DPE	Energy performance diagnosis
ECN	Energy Commission of Nigeria
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EE	Energy Efficiency
EER	Energy Efficiency Ration
ENEA	Italian National Agency for New Technologies, Energy and Sustainable Economic Development
EPBD	Energy Performance of Buildings Directive (EU)
EPC	Energy Performance Certificates
ESCOs	Energy Services Companies
EU	European Union
GDP	Gross Domestic Product
HVAC	Heating, Ventilation and Air Conditioning
LED	Light Emitting Diodes
MEPS	Minimum Energy Performance Standards
NEEAP	National Energy Efficiency Action Plan
NREEEP	National Renewable Energy and Energy Efficiency Policy
RE	Renewable Energy
REAoL	Renewable Energy Authority of Libya

SCE	Energy Certification System
TOE	Ton of Oil Equivalent
WhC	Italian White Certificates Scheme

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Chapter 1: Regulatory Infrastructure in North-West Africa & Europe

1 Introduction

In the framework of the H2020 funded project ABC 21 Africa-Europe BioClimatic buildings for the XXI century, this report intends to shed light on the current regulatory infrastructure in the EU, NA and WA regions.

1.1. Scope and objectives

Given the high rate of energy consumption in the building sector, the introduction of energy efficiency (EE) measures is becoming a necessity and, in some cases, even an obligation.

Since these EE measures cannot be implemented without an appropriate regulatory framework, it is crucial to analyse the existing regulatory and legal infrastructure in the target countries of North and West Africa and the European Union. The goal is to identify the degree of development of these infrastructures, the obstacles encountered, and the recommendations to be proposed.

1.2. Document Structure

The structure of this report is divided into three main parts. The first part is the general introduction to EE in buildings, which is a highly energy-intensive sector worldwide.

After identifying the scope, objectives and work methodology adopted in the development of this study, the results of the benchmark of the regulatory infrastructure of each of the studied countries are stated, explaining the existence of laws, regulations, standards, and labels. The technical requirements and the scope of each document are identified. The scope concerns the type of building (tertiary or residential), the building component (envelope or appliances) and the classification of the building (new or existing). The analysis of the data collected then made it possible to identify the obstacles hindering the achievement of the objectives of increasing EE in buildings and allowed the formulation of recommendations specific to each country.

Finally, an overall analysis of the state of regulations related to EE in buildings in the three regions studied, namely North Africa, West Africa and the European Union, is explained.

1.3. Work methodology

This report has relied on quantitative and qualitative data collection methods to help inform the benchmark and analysis.

Methods used during the report elaboration included using questionnaires (add them in the annex and reference it here), focused group discussions, interview with key informants and review of existing documents from relevant agencies and other public institutions.

The study was conducted in selected countries from North and West Africa and European Union. The choice of countries was made in such a way as to have representative countries of each of the three regions concerned by this study. Therefore, we have chosen to focus our work on:

- Germany,
- Spain,
- Portugal,
- Italy,
- France,
- Morocco,
- Tunisia,
- Egypt,
- Libya,
- Algeria,
- Ghana,
- Senegal,
- Nigeria.

2. Regulatory infrastructure on EE in buildings

Buildings consume 40% of the EU's energy and 55% of its electricity and produce 36% of its CO^2 emissions [1]. As a result, enhancing the energy performance of buildings and increasing the use of renewable energy are critical steps toward meeting the EU's 2030 targets. However, the rate of existing building renovation is currently quite low – between 1% and 2% of the building stock is renovated each year. [1].

2.1. European Union Level

The EE of buildings was initially addressed by the European Union (EU) by Directive 2002/91/EC, which was the first version of the Energy Performance of Buildings Directive (EPBD). The objective was to establish a legislative framework to boost the energy performance of buildings, thus achieving a highly energy-efficient and decarbonised building stock. The EPBD works as guidance for each country to approve their policies and regulations to comply with the regional standards. Local conditions, indoor climate requirements, outdoor climate, and cost effectiveness are all considered and analysed to establish minimum EE requirements for buildings. With this directive, was introduced EE certificate concept. The European Council approved the EU’s framework for energy and climate action until 2030 in October 2014. In terms of EE, an indicative target of at least 32.5% in 2030 is set based on such current criteria for future energy consumption forecasts [2].

The European Commission in July 2021, within the package "Delivering on the European Green Deal" has set ambitious energy consumption targets and savings. With regards to the 2020 reference scenario, EU countries will need an additional 9% savings from the revised Directive, a 39% efficiency target for primary energy and a 36% for final energy consumption.

The next sections break down the results of all the researched regulatory measures dealing with buildings in each of the aforementioned countries.

2.1.1 Germany

According to the German Energy Agency, buildings account for approximately 35% [3] of total energy consumption in Germany: 38% [3] of all energy is used in detached and semi-detached homes, 39% in apartment buildings and 39% for non-residential buildings. The total amount spent by Germans in 2014 on residential and non-residential buildings is 73 billion euros.

Since 63% [3] of residential buildings were constructed before the first thermal insulation ordinance, the building sector represents a significant opportunity for energy savings. As a result, the German Federal Government has set ambition
us targets for reducing energy consumption in the building sector.
Indeed, by 2050, 80% of primary energy requirements are expected to be reduced [3]. To achieve this goal, the German Energy Agency was established in 2000 to ensure the energy transition through the implementation of pilot projects in EE.

In this context, and to achieve these objectives in terms of EE in buildings, particular importance has been given to the regulatory infrastructure in Germany. According to the Federal Institute for Research on Building, Urban Affairs and Spatial Development, this infrastructure has developed as follows [4]:

The Energy Saving Act was passed in 1976 to improve the trade balance, specifically to reduce the Federal Republic of Germany's reliance on imported energy carriers. It does grant the Federal Government the authority to enact ordinances. Since then, ordinances imposing energy requirements on buildings and their appliances have been enacted based on EnEG.

- In order to comply with the European Directive on Energy Performance of Buildings, The Energy Saving Act was modified. The changes primarily concern the addition of principles for energetic requirements on lighting systems and the issuance of energy certificates. In a subsequent step (2 April 2009), the act was amended to include provisions for implementing the German Integrated Energy and Climate Program ("IEKP 2007"). The most recent amendment, the "Fourth Law Amending the Energy Saving Act" of July 4, 2013, was done to Implement the recast European directive on Energy Performance of Buildings (2010/31/EU),
- Establish the legal basis for the changes included in the most recent amendment of the Energy Saving Ordinance.

The main objective of this amendment is to set the fundamental requirement that new buildings will have to be "Nearly Zero Energy Buildings" (buildings owned and used by public authorities from 2019, all other new buildings from 2021).

EnEG - Energy Saving Act – 2013 [5]	
Document type	Law
Date	2013
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	The Federal Government of Germany
Technical requirements	▪ Set up requirements concerning the thermal insulation of new buildings, ▪ Set up requirements on the energy performance of buildings so they will have to be "Nearly Zero Energy Buildings," ▪ Set up requirements concerning design, selection and construction of systems or installations for heating, ventilation, cooling, lighting and hot water supply, ▪ Set up requirements concerning thermal insulation and technical appliances in case of buildings undergoing major renovations, and–under certain preconditions–to foresee specific requirements for buildings and appliances not subject to any other changes, ▪ Set up requirements concerning the operation of systems and installations for heating, ventilation, cooling, lighting and hot water supply, ▪ Set up requirements on the determination and distribution of costs of collective heating or ventilation systems or systems for the collective supply of hot water, ▪ Define content and use of energy certificates based on energy demand and metered energy, ▪ Set up general requirements on the control of energy certificates and inspection reports.

The first ordinance based on the German Energy Saving Act of 22 July 1976 was the Thermal Insulation Ordinance. It was issued on August 11, 1977, and went into effect on November 1, 1977.

It was the first public law regulation for energy-saving thermal insulation on buildings in Germany (as in most other countries). During its roughly two decades of existence, the ordinance was amended twice before being replaced by the Energy Saving Ordinance 2002:

- Thermal Insulation Ordinance 1977
- Thermal Insulation Ordinance 1982
- Thermal Insulation Ordinance 1995

Thermal insulation ordinance [6] [7] [8]	
Document type	Ordinance
Date	1977–1982–1995
Status	In force
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	The Federal Government of Germany
Technical requirements	▪ Structural thermal insulation must be implemented in accordance with the provisions of this ordinance in order to save energy, ▪ Identification of heat transfer coefficient not to be exceeded for each element of the building and different types of buildings, ▪ Identification of limitation of heat losses in the event of leaks for each element of the building and different types of buildings.

The Heating Appliance Ordinance was issued on 22 September 1978 and came into effect on 1 October 1978. It imposed equipment and dimensioning requirements for central heating systems that use water as the energy carrier and hot water systems. Specific requirements were also imposed on single heaters. Since 1982, it has also included regulations for control system retrofitting.

Requirements for system operation were incorporated into the Heating Appliance Ordinance due to the Heating Plant Operation Ordinance repeal in 1989.

The Energy Saving Ordinance replaced the Heating Appliance Ordinance and the Thermal Insulation Ordinance in 2002.

The ordinance was amended four times.

Heating appliance ordinance [9] [10] [11] [12] [13]	
Document type	Ordinance
Date	1978 – 1982–1989–1994 - 1998
Status	In force
Building's type	All
Building's part	Heating appliances
Building's category	All
Steering body	The Federal Government of Germany
Technical requirements	This ordinance defines: ▪ the types of the heating system concerned by the obligations mentioned, ▪ the accepted exhaust emissions for each type of heating system, ▪ the acceptable ventilation and thermal transmissions rates in heated areas,

	▪ the definition of the installation conditions for heating systems, domestic water heaters and regulation devices according to their type, ▪ the definition of thermal insulation requirements for heating and water pipes.

The heating cost ordinance was issued in 1981 and was amended on 5 April 1984 and on 20 January 1989.

Heating cost ordinance [14] [15] [16]	
Document type	Ordinance
Date	1981 – 1984–1989
Status	In force
Building's type	All
Building's part	Heating appliances
Building's category	All
Steering body	The Federal Government of Germany
Technical requirements	The Heating Cost Ordinance governs how heating and hot water costs are allocated in centrally supplied buildings with two or more units. Additionally, the obligation of consumption metering and the technical equipment for metering are regulated. Residential buildings with only two dwellings, one of which is occupied by the building owner and (in terms of thermal heat) retirement and nursing homes, halls of residence for students or apprentices, and comparable buildings or parts of buildings, are exceptions.

Based on the EnEG 1977, the Heating Plant Operation Ordinance was issued to issue requirements for the maintenance of EE in the operation of central heating systems with water as a heat carrier and systems for hot water generation.

The ordinance is aimed at the operators of such systems and only applies to systems in supplied buildings, not to those in heating plants and similar facilities.

Heating plant operation ordinance [17]	
Document type	Ordinance
Date	1978
Status	In force
Building's type	All
Building's part	Heating appliances
Building's category	All
Steering body	The Federal Government of Germany
Technical requirements	This ordinance defines: ▪ the heating systems concerned, ▪ the rate of gas exhaust losses accepted according to the power of the heating system,

	▪ the maintenance requirements for each type of heating system.

The Energy Saving Ordinance was first issued on November 16, 2001, and went into effect on February 1, 2002. It superseded the German Thermal Insulation Ordinance of 1995 and the Heating Appliance Ordinance of 1998. The ordinance has been re-issued and amended three times since then.

The currently (from 1 May 2014) valid version is the Energy Saving Ordinance 2013.

Energy-saving ordinance 2014 [18]	
Document type	Ordinance
Date	2014
Status	In force
Building's type	All
Building's part	All
Building's category	New buildings
Steering body	The Federal Ministry for Economy and Energy (BMWi) and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)
Technical requirements	The ordinance sets up: ▪ Special regulations apply to the consideration of electricity generated from renewable sources (primarily photovoltaic) in the vicinity of the building and used by the building's services. ▪ The fundamental requirement for building the thermal envelope airtight by widely accepted technical standards, ▪ minimal thermal insulation rules and the basic rule for reducing the influence of thermal bridges, ▪ Special provisions apply to small buildings (up to 50 m^2) and temporary structures built with certain prefabricated modules. ▪ Requirements for the configuration (controls, pipe insulation) of heat distribution systems and domestic hot water systems, applicable to new buildings (among others). ▪ Requirements for the configuration and design of air conditioning and ventilation systems, applicable to new buildings (among others). ▪ Rules for the situation in which a building is used partially as a residential and partially non-residential building. Rules for transitioning from the previous status of legislation to the current status of legislation (i.e.: date of validity of new provisions). Besides the general requirements for new buildings, for residential buildings, the following requirements apply: ▪ Limitation of annual primary energy demand by a maximum value determined on an individual basis ("overall energy performance"), ▪ Specific transmission heat loss per square meter of building shell limitation ("requirement on thermal insulation"), ▪ Limitation of solar irradiation indicators or over-temperature degree hours in accordance with DIN 4108-2 ("summer heat protection").

	The requirements are tailored to the specific building task. The size of the building, its shape and orientation, and the relative share of the shell components may limit the ability to reduce primary energy demand and transmission heat loss. As a result, in Germany, maximum values are determined using the reference building approach.

Energy-saving ordinance 2014 [18]	
Document type	Ordinance
Date	2014
Status	In force
Building's type	All
Building's part	All
Building's category	Existing buildings
Steering body	The Federal Ministry for Economy and Energy (BMWi) and the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)
Technical requirements	**Conditional requirements** Suppose the owner of an existing building makes specific alterations to shell components belonging to heated or cooled space as specified in Annex 3 of the ordinance (primarily: refurbishment measures). In that case, the resulting heat transmission coefficient requirements must be met by the portion of the surface covered by the measure. This does not apply when the measure's coverage is insufficient. This does not apply if the measure's coverage does not exceed 10% of the total surface covered by this type of shell component on the entire building. **Mandatory upgrade requirements** The ordinance requires mandatory upgrades of certain parts of the building in certain cases (exchange of old boilers, insulation of certain pipes, insulation of top ceilings, and installation of certain control devices in heating- and AC-systems). **Requirements in case of extensions** In the case of extensions, the ordinance differentiates the requirements for the new parts of the building. **Requirements in case of new installation or add-ons of heating, ventilation and air conditioning systems** The ordinance makes no distinction between building services (heating, ventilation, and air conditioning systems) in new and existing buildings. Certain minimum requirements must be met in terms of control devices and system insulation.

Chapter 5 of the Energy Saving Ordinance lays out the legal foundation for energy certificates. The regulations address:

- The various occasions when energy certificates become mandatory,
- The use and principles of energy certificates,

- The layout and structure of forms,
- The requirements for recommendations to be included in certificates,
- The skills required to be an issuer for existing buildings.

Energy certificates [4]	
Document type	Certificates
Date	2014
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	German Institute for Building Technology
Technical requirements	The energy certificate is only for informational purposes. The information contained in the energy certificate pertains to the entire building or the portion of the building described. The energy performance certificate is only meant to allow for a rough comparison of buildings. Energy certificates are necessary: ▪ after the completion of a new building ▪ if - in correspondence with refurbishment measures or a larger extension - an energetic balance for the entire building is calculated ▪ with sale or renting of buildings or parts of buildings (e.g., apartments) ▪ for display on certain buildings of public service frequently visited by the public. It includes: ▪ Building use and zones, ▪ Notes on the information on the energetic quality of the building, ▪ Primary energy demand, ▪ Final energy demand, ▪ Final energy demand for heating and hot water, ▪ Final energy demand for electricity.

The Council and Parliament of the European Union legislated the Directive 2002/91/EC on the EE of buildings on December 16, 2002. With the Energy Saving Act 2002, Germany had already implemented most of the directive's provisions. Following the passage of the Energy Saving Act in 2007, all of the directive's requirements were fully implemented in Germany.

Energy Performance of Buildings Directive (2002/91/EG) [19]	
Document type	Directive
Date	2007
Status	In force
Building's type	All
Building's part	All

Building's category	All
Steering body	The Federal Ministry of Transport, Building and Urban Development, the Ministry of Economics and Technology and the Ministry of Environment, Natural Conservation and Nuclear Safety.
Technical requirements	"*This Directive lays down requirements as regards:* ▪ *the general framework for a methodology of calculation of the integrated energy performance of buildings,* ▪ *the application of minimum requirements on the energy performance of new buildings,* ▪ *the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation,* ▪ *energy certification of buildings,* ▪ *regular inspection of boilers and of air conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old*."

The new Buildings Energy Act (GEG) was published in the "Bundesgesetzblatt" on August 13, 2020 (Official Journal for Federal Legislation). It will replace the previous Energy Saving Act, the previous Energy Saving Ordinance, and the previous Renewable-Energies-Heat Act on November 1, 2020.

Building energy act [20]	
Document type	Law
Date	2020
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	The Federal Government
Technical requirements	The building energy act includes requirements for building energy quality, the creation and use of energy cards, and the use of renewable energies in buildings. In addition, the new requirements of the Building Energy Act are: ▪ Introduction of a new equivalent method to demonstrate compliance with the energy requirements for the construction of residential buildings, ▪ The obligation of using renewable energies in the new building by using electricity generated near buildings from renewable energies, ▪ Regulation of primary energy factors to be used in the calculation of the permissible annual primary energy demand, ▪ carbon dioxide emissions of a building resulting from the primary energy demand or primary energy consumption will be indicated in energy data cards.

The Energy Saving Ordinance is dealing with technical issues which are verified by technical calculations. The calculation methods are specified in several technical standards developed by the German Institute for Standardisation (DIN). The most important standards in EE in the buildings field are:

DIN V 18599 series	
Document type	Standard
Date	2014
Status	In force
Building's type	Non-residential buildings
Building's part	Appliances
Building's category	All
Steering body	German Institute for Standardisation (DIN)
Technical requirements	DIN V 18599 standard series provide a procedure for assessing the energy performance of buildings. The calculations allow the assessment of all amounts of energy necessary for the intended heating, hot water heating, ventilation conditioning and lighting of buildings.

The Passive House Institute has established several standards relating to buildings in general and others focusing on building components in order to contribute to the development of EE in buildings. Passive house standards apply to all countries around the world, regardless of their climatic conditions.

Passive house Standard [21]	
Document type	Standard
Date	2015
Status	Voluntary
Building's type	All
Building's part	All
Building's category	New buildings
Steering body	Passive House Institute
Technical requirements	There are three Passive House Standard categories depending on the renewable primary energy demand and generation of renewable energy. The technical requirements concern: ▪ Heating demand, ▪ Cooling and dehumidification demand, ▪ Pressurization test result n50, ▪ Renewable Primary Energy demand, ▪ Renewable energy generation (with reference to projected building footprint). The criteria of the passive house standard apply to all climates worldwide.

EnerPHit Standard	
Document type	Standard
Date	2015
Status	Voluntary

Building's type	All
Building's part	All
Building's category	Existing buildings
Steering body	Passive House Institute
Technical requirements	Depending on the climatic zone defined by the PHPP, technical requirements are required and graduated to have a classic, plus or premium certification. These requirements relate to: ▪ the thermal transmission coefficients of the opaque walls and windows, ▪ the ventilation and humidification rate of the building, ▪ solar load during cooling periods, or ▪ the heating, cooling and humidification demand. General requirements are also required: ▪ pressurization test result n50, ▪ Renewable Primary Energy demand, ▪ renewable energy generation.

Low Energy Building Standard [21]	
Document type	Standard
Date	2015
Status	Voluntary
Building's type	All
Building's part	All
Building's category	Specific buildings
Steering body	Passive House Institute
Technical requirements	The PHI Low Energy Building Standard is suitable for buildings that do not fully comply with Passive House criteria for various reasons. The technical criteria for this standard are related to: ▪ heating demand, ▪ cooling and humidification demand, ▪ pressurization test result n50, ▪ renewable Primary Energy demand, ▪ renewable energy generation.

Passive House Component certification [21]	
Document type	Certification
Date	2015
Status	Voluntary
Building's type	All
Building's part	Envelop

Building's category	All
Steering body	Passive House Institute
Technical requirements	Depending on the climatic zone, technical requirements related to the efficiency criterion must be met to be certified. The building component concerned by this standard are: ▪ Transparent components (window frames, frames for fixed glazing, sliding doors, entry doors, curtain wall systems, roof windows, skylights, glazing), ▪ Sun protection (roller shutter/external blinds) and window installation systems.

The regulatory infrastructure related to EE in buildings in Germany is highly developed when compared to other countries. It is continuously updated, taking into consideration new global guidelines and technological advancements in this field. It gives great importance to bioclimatic and positive energy buildings as well as the promotion of energy production from natural resources. This regulatory infrastructure is updated according to climate change; however, it does not take into consideration future climate forecasts. The passive part of the building is the basis of all regulations in Germany. Therefore, the renovation and insulation of the envelope are of major importance.
However, there are still some obstacles that prevent the country from fully unleashing its potential. They are specially defined in the "Energy Performance Certificates across Europe From design to implementation" report [22]:

(1) Public acceptance and use of energy certificates:

According to a recent study on the market development of the use of Energy Performance Certificates in Germany (BMVBS, February 2010), approximately 87% of social housing organizations have EPCs for a large portion of their building stock. Only about 30% of private building owners and landlords are estimated to have an energy performance certificate at the time of rent or sale. The general public is frequently unaware of the requirement to issue an EPC, or it is not done because renters or buyers do not request one. The EPC is rarely a deciding factor in the sale or rental of a building.

(2) Awareness and compliance enforcement:

Despite the fact that DENA has conducted several awareness campaigns about the requirement for Energy Performance Certificates, many private building owners are not properly informed. In fact, the government has imposed penalties for non-compliance with the EPC obligation at the time of the transaction, but there is no operational enforcement system. Municipalities are, in theory, responsible for monitoring compliance, but in practice, compliance is often only checked when a complaint is filed.

(3) Quality control:

The different types of energy performance certificate and the various application methods in different states in Germany influence their quality. Other obstacles have been identified by the campaigning for the future report-2010 [23], which are mainly:

- **Insecurity of homeowners relating to legislation,**
- **Lack of technical information regarding useful energetic refurbishment measures,**

- **Diversity of subsidy schemes,**
- **Economic efficiency of measures (payback time).**

The diversity and advanced development of regulations and incentive programs in terms of EE in buildings in Germany is positive. All the same, this created an ambiguity among citizens and technicians in the field, not knowing which regulations to apply and which program is best suited to their situation.

Therefore, an essential recommendation in the case of Germany is the homogenization of laws and regulations at the national level, and the establishment of an effective awareness system allowing everyone to locate themselves and choose the best alternative allowing it to save the maximum.

2.1.2 Spain

The 2017–2020 National Energy Efficiency Action Plan is the general framework for EE policies in Spain. This plan is the second Action Plan required by Directive 2012/27/EU and the fourth (NEEAP4) pursuant to article 14 of Directive 2006/32/EC, of 5 April 2006 on energy end-use efficiency and energy services. This provides continuity to the Action Plans of the 2004–2012 Energy Saving and Efficiency Strategy (E4), as well as the Action Plans that followed, 2011–2020 (NEEAP2) and 2014–2020 (NEEAP3). The Plan integrates a vast array of instruments and measures to fulfil the energy targets undertaken by Spain concerning articles 3 and 7 of the Directive, which define EE concepts and the exchange of information, respectively. At the sector level, transport and buildings stand out as the recipients of the largest number of measures. In what concerns buildings, beyond the legislative measures developed in response to Directive 2010/31/EU on the energy performance of buildings, there are a number of programs and measures intended to renovate buildings for the purpose of improving EE, focusing especially on buildings belonging to the public administration owing to their exemplary role. [24]

Law 8/2013 on Urban Renovation, Regeneration and Renewal	
Document type	Law
Date	2013
Status	Ended 2020
Building's type	All
Building's part	All
Building's category	Residential
Steering body	The Ministry of Housing and the Ministry of Industry, Tourism and Trade/IDAE
Technical requirements	Obligation for buildings to have an evaluation report consisting of three documents, one of which is the building's energy certificate.

The purpose of the law is to regulate the basic conditions that will ensure sustainable, competitive, and efficient development of the urban environment, by means of driving and promoting actions that will lead to the renovation of buildings and the regeneration and renewal of the existing urban fabric, where necessary, to ensure a suitable quality of life for citizens and the effectiveness of their right to enjoy decent and adequate housing.

Royal Decree 235/2013 approving the basic procedure to certify the energy efficiency of buildings	
Document type	Royal Decree//Certification
Date	2013
Status	In force
Building's type	Residential
Building's part	All
Building's category	All
Steering body	The Ministry of Housing and the Ministry of Industry, Tourism and Trade/IDAE
Technical requirements	Obligation to provide the buyers or users of buildings with an energy efficiency certificate that must include objective information on the energy efficiency of the building and reference values, such as minimum energy-efficiency requirements. It likewise establishes the basic procedure to be followed in calculating the energy efficiency rating. In order to assist in the fulfilment of the provisions of Royal Decree 235/2013, software with which to calculate the energy rating of new and existing buildings has been made available to the public (HULC for new buildings, CE3 and CE3X for existing buildings).

The Royal Decree establishes the obligation to provide buyers/users of buildings with an EE certificate, in which must include objective information about the EE of a building and reference values, e.g., minimum EE requirements, so that the owners or tenants of the building or unit within it can compare and evaluate its EE.

Norm on building thermal insulation in Catalonia region	
Document type	Norm
Date	1987
Status	In force
Building's type	Residential, Commercial, Industrial and Public
Building's part	All
Building's category	All
Steering body	Department of Policy and Public Works of the Catalan Government
Technical requirements	It is an updating of the Basic Buildings Standards for Thermal Insulation (Norm NBE-79) and it was written taking into consideration: ▪ Avoiding the price increase of building sector. ▪ Decrease of the heating consume. ▪ Simplicity of application. ▪ Easiness of verifying its completion.

Action Plan 2005–2007	
Document type	EE Strategy Action Plan
Date	2005

Status	In force
Building's type	Residential, Commercial, Industrial and Public
Building's part	All
Building's category	All
Steering body	The Ministry of Housing and the Ministry of Industry, Tourism and Trade/IDAE will manage the economic aid related to the energy rehabilitation of buildings.
Technical requirements	▪ Renovation of the thermal envelope of existing buildings (SPA 26). ▪ Improvement of the energy efficiency of thermal installations in existing buildings (SPA 27). ▪ Improvement of the energy efficiency of indoor lighting installations in existing buildings (SPA 28) ▪ Regulatory measures for the implementation in Spanish law of Directive 2002/91/EC on the Energy Performance of Buildings (SPA 29).

Basic Building Standards for Thermal Insulation – NBE-79	
Document type	Mandatory Standards
Date	1979
Status	Ended. Replaced by 2002 "Save Directive"
Building's type	all projects for private or public building constructions.
Building's part	Envelope
Building's category	All
Steering body	The administrations of autonomous regions are the key actors responsible for the enforcement of these standards.
Technical requirements	The upper limit for overall thermal transmission "Kg" of the building (kcal/h m^2 ^{0}C or W/m^2 ^{0}C) varies with the climate of the area and the type of energy used for heating, ranging from 2.10 to 0,45 kcal/h m^2 (2,45 to 0,52 W/m^2 ^{0}C).

Action Plan 2011–2020	
Document type	EE Strategy Action Plan
Date	2011
Status	Ended
Building's type	Residential, Commercial, Industrial and Public
Building's part	All
Building's category	All
Steering body	The Ministry of Housing and the Ministry of Industry, Tourism and Trade/IDAE will manage the economic aid related to the energy rehabilitation of buildings.

Technical requirements	▪ Improvement of the energy efficiency of the electric appliances stock (SPA22) Renewal of the thermal casing in the existing buildings (SPA30; Household sector) ▪ Improvement of energy efficiency of the thermal installations in existing buildings (SPA31; Household sector) ▪ Improvement of energy efficiency of the indoor lighting installations in existing buildings (SPA32; Household sector) ▪ Construction of new buildings and rehabilitation of the existing ones with high energy qualification (SPA33; Household sector) ▪ Construction or rehabilitation of nearly-zero energy buildings (SPA39; Household sector) ▪ Renewal of the thermal casing in the existing buildings.

The action plan 2011–2020 establishes a final energy saving objective of 2.867 Mtoe for the year 2020 in the Building and Equipment sector corresponding to the Services and Household sectors. This objective involves avoided emissions of around 12.120 MtCO2. For these purposes, investments worth 27,322 M€ and public aids worth 2,883 M€ will be necessary. The group of measures within the Action plan 2011–2020 for the household sector is aimed at the buildings used as dwellings and the home equipment.

State Plan 2013–2017 for Rental Housing, Housing Rehabilitation, and Urban Regeneration and Renewal	
Document type	EE Strategy Action Plan
Date	2013
Status	Ended
Building's type	Residential, Commercial, Industrial and Public
Building's part	All
Building's category	All
Steering body	Regional Governments and the Autonomous Cities of Ceuta and Melilla.
Technical requirements	Promotion of renting and promotion of rehabilitation and urban regeneration and renovation; the reactivation of the real estate sector from the two driving forces stated (promotion of renting and support of building rehabilitation and urban regeneration); the improvement of building quality and particularly, of its energy efficiency and adaptation for waste collection and management.

2.1.3 Portugal

2.65 Mtoe, or 17% of Portugal's energy consumption in 2018 is attributed to the residential sector. Thanks to its policy measures, space heating has seen a drastic decrease of 36%, in comparison to 2003.

Next to space heating, cooking is the second-largest energy consumer in dwellings, which gravitates at 51%, and this is after a 29% decrease since 2009. With air conditioning only representing 1%, water heating and electric equipment together account for 23% and 25% respectively. [25].

Efficiency in Residential Buildings	
Document type	Mandatory Information
Date	2008
Status	Ended 2015
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	ADENE
Description	The objective of this measure is to certify 475 thousand homes in new or rehabilitated buildings by 2015

The Energy Certification System includes mandatory shares of efficient classes for new buildings and large rehabilitation works. Additionally, specific regulations may be developed, aimed at encouraging improvements in the energy classes of existing buildings.

Solar Thermal Program	
Document type	Mandatory Standards
Date	2008
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	
Description	The objective to achieve with the thermal micro production measure is creation of a sustained market, representing installation of 175,000 m^2 of solar collectors per year, which will result in approximately 1.4 million m^2 of installed operational collectors by 2015, corresponding to approximately 1 in 15 buildings with Solar Thermal systems.

Energy Certification of Buildings	
Document type	Decree-Law 118/2013
Date	2013
Status	In force
Building's type	Building professions Housing associations Landlords Owner-occupiers
Building's part	All
Building's category	All

Steering body	Associations Central government Energy agencies
Description	Define the working model of the Energy Certification System (SCE) Within the SCE, energy certificates are required in the following occasions: ▪ New buildings, in the design phase and before the use permit concession ▪ Buildings that undergo a major renovation, in the design phase and before the use permit concession ▪ Existing buildings from the moment they are rented or sold, including the moment they're advertised for that purpose where the energy label has to be shown.

Buildings codes on thermal performance characteristics	
Document type	Regulation
Date	2005
Status	In force
Building's type	Building professions General public Housing associations Landlords Owner-occupiers
Building's part	All
Building's category	All
Steering body	Associations Central government Energy agencies
Description	This new version establishes stricter conditions for building design in compliance with the European Directive n. º 2010/31/UE in what concerns to, for example: ▪ Building components requirements for new and renovated buildings. ▪ Technical systems requirements (heating, cooling, ventilation, and hot water production) also for new and renovated buildings.

EU's Energy Labelling framework Regulation	
Document type	Energy Labelling
Date	2017
Status	In force
Building's type	All

Building's part	Envelope and appliances
Building's category	All
Steering body	Central government Local government
Description	To this end the Regulation presents three main novelties: ▪ The rescaling of the label's energy class, progressively eliminating the "A plus" classes, recovering the A to G energy class. ▪ Upon the rescaling process, to leave the top class, or two top classes, empty to encourage technological progress. ▪ To create a product database, with public and private access, where the supplier is responsible for the upload of information regarding new products placed on the market (and products that were placed on the market between the 1st of August 2017 and 1st of January 2019).

Energy Consumption Labelling Ordinance	
Document type	Mandatory information - Labels - Mandatory labelling electrical appliances
Date	1994
Status	In force
Building's type	All
Building's part	electric appliances
Building's category	All
Steering body	Central government Energy agencies Industries Local government
Description	Within these legislative documents, it is established the rules and procedures relative to the minimum requirements of energy efficiency in the several household appliances: washing machines, tumble dryers, combined washing and dry machines, refrigerators and freezers, household lamps and electric ovens.

The Portuguese building code permits the use of bioclimatic approaches since energy performance and thermal comfort requirements are achieved. In addition, the weather files considered until now to analyse buildings under the building code represent a typical year (only 30 years of past weather, TMY format). However, new weather files are being prepared for be in use from 2022 that also considers future climate.

As in bioclimatic approaches, all newly developed technologies could be considered since energy performance and thermal comfort requirements are achieved.

2.1.3 Italy

Italy has values of primary energy intensity lower than the average of the countries of the European Union than to those outside the Eurozone [26]. The country was able to maintain a steady yearly improvement in EE in the residential sector of 1.2% between 2006 and 2016, making the 2020 target set by the National Energy Efficiency Action Plan (NEEAP) achievable 3 years ahead of time [27].

To reach this target, Italy relied on a set of legislations and market policies to encourage energy savings in the building sector, including both construction and renovation. As a matter of fact, the Italian construction sector is a particularly important part of the national economy as it accounts for 18.8% of Italy's GDP. The renovation of the existing building stock represented 37% of the total investments in the construction sector in 2016 [28].

Below are factsheets on the current Italian policies on EE in buildings.

The Italian White Certificates Scheme	
Document type	Regulation
Date	2005
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development
Description	The Italian White Certificates Scheme (WhC) is a market-based and technology-inclusive, and tradable incentive mechanism for large and medium end users and energy service companies. The support scheme puts an obligation on electricity and natural gas distributors with more than 50.000 customers of achieving a quantified target of energy savings yearly (7.6 Mtoe/year in 2016). White certificates cover 60% of the national target set by the 2006/32/EC directive, and attest the achievement of end-use energy savings through energy efficiency improvement in industry, residential and public sector [29].

The Decree of the President of the Republic no. 412/93 on energy performance for buildings	
Document type	Regulation
Date	2005
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development

Technical requirements	The Decree of the President of the Republic no. 412/93 established a comprehensive framework for the energy performance evaluation of newly erected and existing buildings. The Decree 412/93 established principles and methodologies for the evaluation of: ▪ Building and thermal equipment systems ▪ Design norms for the building shell ▪ Thermal equipment

Energy Performance of Buildings (Directive 2002/91/EC) - Energy Performance of Buildings	
Document type	Regulation
Date	2006
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development
Technical requirements	To ensure compliance with the Energy Performances of Buildings Directive (EPBD), the Legislative Decree n.192/2005, as amended by Legislative Decree n.311/2006 and complemented by Legislative Decree 115/2008, establishes a general framework for enforcing the following measures: ▪ The establishment of calculation methods and minimum requirements for new and renovated buildings. ▪ The establishment of an "Energy Certification" program for buildings. ▪ The establishment of routine inspections for boilers and air conditioning.

Tax deduction scheme for the energy renovation of existing buildings (Eco-bonus)	
Document type	Incentive
Date	2007
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development
Technical requirements	Introduced by Financial Law 2007, the original measure was revised and updated/extended on several occasions. For instance, the Legislative Decree of 29 November 2008 extended the time

	limit for the allocation of deductions of tax to up to five years, followed by Law no. 220 of 13 December 2010. By the legislative decree of 4 June 2013, the 55-percent tax deduction was also increased to 65%. There has also been an increase in the number of allowable interventions. The substitution of traditional water heaters was introduced by the Decree of 6 December 2011, the Stability Law 2015 included biomass boilers and solar protection systems and the Stability Law 2016 also added multimedia air conditioning and hot water remote monitoring devices. Finally, the 2018 Finance Law reduces the tax deduction for the purchase and installation of windows, window frames, and solar protection from 65 to 50%. Furthermore, it confirms the 70% and 75% deductions until 2021. Currently, the deduction is currently divided into ten equals annual instalments and is applicable to the following types of work performed to improve the energy performance of existing buildings: ▪ 55% of costs incurred until 5 June 2013. ▪ 65% of costs incurred in interventions in individual units from 6 June 2013 to 31 December 2017. ▪ 65% of costs incurred in interventions in common parts of apartment blocks or all of its units from 6 June 2013 to 31 December 2021. ▪ 70% of costs incurred in interventions in common parts of apartment blocks or all of its units from 6 June 2013 to 31 December 2021 [1].

Despite the success of the measure (Eco Bonus) and the low cost and high savings recorded from the improvement of building envelopes [30], two problems that the government should take into consideration have been identified. To begin with, the costs of energy efficiency interventions on residential buildings remain considerably higher than the typical levels of the industrial sector, with the same savings obtained. The cost-effectiveness ratio of tax deductions and thermal accounts is up to four times higher than with the white certificate mechanism (8.6 c€/kWh vs. 2.9 c€/kWh) [31]. Secondly, the Eco Bonus presumes that families are in possession of sufficient financial means to invest in energy saving renovation, without giving consideration to those families that do not and/or are living in energy poverty [32].

Application of calculation methodologies for energy performance and definition of buildings minimum requirements	
Document type	Regulation
Date	2015
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development, ENEA, Regional Authorities

Technical requirements	This measure appeared in The Ministerial Decree 26 June 2015 along with two other decrees. The Ministerial Decree completes the transposition of the European Directive EPBD 2002/91/CE and modifies the Decree 192/2005. The measure defines the requirements of nearly zero-energy buildings and set the new minimum energy performance and single component requirements. A new calculation methodology for the energy performance is introduced, based on a comparison with a reference building with the characteristics defined in the decree. All energy use required to comply with the building's usage standard is included in the calculation of the building's energy performance, which refers to different classes. **Prescriptive Compliance path:** According to the new computation method for the energy performance of buildings, energy demand is derived for a reference building, namely a building identical to the analysed one, but with the thermal and energy characteristics defined in the Decree. The analysed building, after energy renovation, should have a total energy demand lower than the reference building. The parameters for the existing building (interested by energy requalification) are provided in order to be used for the calculation of total energy demand [33].

Reference scheme for the technical project reports to apply buildings minimum requirements	
Document type	Regulation
Date	2015
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development, ENEA, Regional Authorities
Technical requirements	This is the second measure of the Ministerial Decree 26 June 2015. In this second decree, the format for technical project reports is defined, relative to new and nearly zero-energy buildings, relevant retrofitting, and technical installations.

Upgrade of national guidelines for energy certification of buildings	
Document type	Regulation
Date	2015
Status	In force
Building's type	All

Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development, ENEA, Regional Authorities
Technical requirements	As a part of the Ministerial Decree 26 June 2015, this last decree includes the national guidelines for Energy Performance Certificates (EPC). A unique information system harmonising Energy Performance Certification in the different regions was also set for all Italian regions, aimed at the management of a national registry of EPC and thermal installations, to be created by ENEA and the regions by the end of 2015. Regions are now adopting the new guidelines in force from 1 October 2015 and those who already implemented EPBD2 had 2 years 'period to adapt to the new national methodology. The past rating system with 8 classes: A+ / A / B / C / D / E / F / G established on the basis of a fixed range of energy performance index (kWh/mq), is replaced by a new rating system based on 10 adaptable classes (A4 / A3 / A2 / A1 / B / C / D / E / F / G), based on a range proportional to the energy performance of a virtual reference building (identical to the real one as for geometry, orientation, location in the climatic zone, use, etc.) but with predetermined thermal characteristics and energy parameters [34].

Conto Termico 2.0	
Document type	Regulation
Date	2016
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development
Technical requirements	Conto Termico (Thermal Account) encourages interventions aiming to increase of energy efficiency and produce thermal energy from renewable sources for small installations. The beneficiaries are mainly public administrations, but also companies and individuals, who were able to access funds for 900 million euros per year, of which 200 are for public administration. Thanks to the Thermal Account, it was possible to redevelop buildings to improve their energy performance, thus reducing consumption costs and recovering part of the costs incurred in a short time. Recently, the Thermal Account has been renewed with respect to the one introduced by the Ministerial Decree of 28/12/2012. Two categories of projects were eligible to benefit from the scheme:

	A) energy efficiency improvements in an existing building and B) small-scale projects concerning systems (<2000 kW) producing thermal energy from renewable and high-efficiency system. **Eligible technologies:** A.1) isolations of opaque surfaces, replacement of transparent closures, installation of system shielding and shading and replacement of generators with appliances condensation. B.1) heat pumps, biomass boilers, heaters and fireplaces, solar thermal systems, including those based on the solar cooling technology [35].

Legislative Decree 10 June 2020, n. 48	
Document type	Regulation
Date	2020
Status	In force
Building's type	All
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Economic Development
Description	The Legislative Decree n. 48 of 10 June 2020 transposed the Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. The Decree changes the requirements for calculating energy performance of buildings and those for the activities of installers and energy certifiers and provides for the adoption of the long-term strategy within 30 days of its entry into force, therefore by 11 July 2020.

In addition to the previous regulations, energy audits are mandatory for large enterprises and "energy-intensive" enterprises according to Article 8 (1) and (3) of Legislative Decree Nº 102/2014.

In the building regulations, it is widely recognized that bioclimatic could help to achieve the strict standards prescribed by the law in terms of energy performance.

For instance, from the 1st of January 2021, all the new buildings must achieve the nZEB target, that requires high energy performance (also obtained by a wide use of renewable sources) and the minimization of energy consumptions. It is reachable through the right choice and application of passive strategies, such as a compact shape of building, the best orientation possible, improvement of shading systems with advanced control, the best Window/Wall ratio possible. All these actions are not explicit in the legislative framework, but they are good practices and necessary to satisfy the minimum standard requirements. Moreover, the Inter-ministerial Decree 26 June 2015 or "Minimum Requirements Decree" imposes high levels of

insulation in building envelope components (low levels of transmittance for building in roofs and external walls, double or triple windows) and thresholds for the overall average coefficient of heat transfer by transmission and for the summer solar equivalent area related to the net surface area of the building.

The minimum requirements and the nZEB target provided by the building code as well as national incentive and financial tools lead to the use of newly developed technologies that are becoming more and more efficient. Moreover, the cited regulations start from the issues due to the climate change and are in accordance with the European objective of reduction of CO2 emissions and achievement of the carbon neutrality by 2050. Furthermore, the Italian Government has recently published the Integrated National Energy and Climate Plan [36] and the Italian National Long-Term Renovation Strategy (LTRS) [37]. These documents contain the Italian aims, strategies, and action proposals to achieve the European objective of energy consumption reductions and decarbonized building stock within 2050.

2.1.4 France and overseas territories

In terms of energy consumption, the construction sector accounts for 43% of yearly energy consumption and 23% of greenhouse gas (GHG) emissions in France. France supervises, supports, and educates stakeholders in the sector in order to enhance the energy performance of existing and new buildings.

France has made a number of initiatives and activities to help the world progress toward zero-emission global real estate that is both efficient and climate-resilient [38]:

- Join the Global Buildings and Construction Alliance (Global ABC) formed at COP21. Its goal is to create a shared vision of the transition and to reinforce real estate commitments,
- Since March 2018, the Energy Efficiency in Buildings Program (PEEB) has been in operation. Within the scope of the Global Buildings and Construction Alliance, France and Germany launched this assistance program. Its first phase aims to raise 1.4 billion euros in funding and increase the capacities of low-carbon real estate transition initiatives in developing nations,
- The Nearly Zero Energy Building campaign (NZEB campaign) was launched in 2017 as part of the Clean Energy Ministerial and the Global Buildings and Construction Alliance, with the goal of encouraging governments and businesses to participate in decarbonization efforts.

In this perspective, a plethora of laws, regulations, and labels are published and reviewed on a regular basis [39].

Creation of ADEME [40]	
Document type	Law
Date	1991
Status	In force
Building's type	All
Building's part	All
Building's category	All

Steering body	Ministries of Research and Innovation, Ecological and Inclusive Transition, Higher Education.
Description	The Ecological Transition Agency, formerly known as the Agency for the Environment and Energy Management (ADEME), is a French public industrial and commercial establishment (EPIC) founded in 1991. Law No. 90–1130 of December 19, 1990, and Decree No. 91–732 of July 26, 1991, control it. It is overseen by the ministries of Research and Innovation, Ecological and Inclusive Transition, Higher Education. The Environmental Code defines the nature, missions, organization, and operation of ADEME, the agency works in a variety of ways: ▪ By funding research on sustainable, cost-effective transportation systems, building energy efficiency, and innovative energy technology. ▪ By providing financial and technical support for feasibility studies that enable developers to implement more energy-efficient solutions. ▪ By stimulating the adoption of illustrative, motivational operations relating to energy efficiency, and by making it easier for people to do so.

The energy usage of new buildings has been split by two since the first thermal regulation was implemented in 1974, and this was before 2012. Thanks to the Thermal regulation 2012, the Grenelle de l'Environnement has divided this consumption target by three times. In new building, the energy consumption ceiling of 50 kWhep/m^2/an (primary energy calculation) has become the standard. RT2012 paves the way for even more energy-efficient buildings in 2020, when new energy and environmental rules will be required.

Thermal regulation 1974 – 1976 [41]	
Document type	Decree
Date	1974–1975
Status	In force
Building's type	New buildings
Building's part	All
Building's category	Residential
Steering body	Ministry of Environment
Description	This regulation aims to reduce the energy consumption of buildings by 25% by ▪ Thermal insulation of the walls (G coefficient) ▪ Automatic adjustment of the heating systems.

ECODOM Label in la Réunion and Antilles [42]	
Document type	Label
Date	1997

Status	Voluntary
Building's type	New buildings
Building's part	All
Building's category	Residential
Steering body	ADEME
Description	This label is awarded to residential buildings which have technical requirements related to the installation of: ▪ Sun protection for the roof, walls and windows, ▪ Natural ventilation and air fans, ▪ Production of domestic hot water, ▪ Air-conditioned room. This label emphasizes the importance of bioclimatic buildings by defining recommendations related to orientation, town planning, topography, microclimate and vegetation to be taken into consideration in this regard.

Thermal regulation 2000 [43]	
Document type	Regulation
Date	2000
Status	In force
Building's type	New buildings
Building's part	All
Building's category	All
Steering body	Ministry of Ecological Transition
Description	▪ The conventional energy consumption of a building for heating, ventilation, air conditioning (in 2003), domestic hot water, auxiliaries, and for buildings other than residential lighting, expressed in the form of the coefficient C in (kWhep) primary energy, should be less than or equal to a conventional retention energy consumption, expressed in the form of C ref coefficient. ▪ In the summer, the conventional indoor temperature (°C) reached by a non-air-conditioned building, denoted Tic, must be less than or equal to the conventional interior temperature reference, denoted Tic ref, which corresponds to the maximum value of the mean on three consecutive hours of operating temperature. ▪ The thermal insulation properties of walls, windows, heating equipment, ventilation, domestic hot water, air conditioning, lighting, and sun protection meet or exceed the minimum thermal characteristics stipulated in Title III of the order of November 29, 2000.

Thermal regulation 2005 [44]	
Document type	Regulation
Date	2005
Status	In force
Building's type	New building
Building's part	All
Building's category	All
Steering body	Ministry of Ecological Transition
Description	▪ Energy savings: the global energy consumption for heating, domestic hot water, cooling, auxiliary stations, and lighting (in the case of a tertiary building) must be less than the reference consumption of this building. In addition, RT 2005 establishes an upper limit for consumption for households. These buildings' energy usage for heating, cooling, and domestic hot water must be below a certain threshold, which varies depending on the kind of heating and the environment. ▪ Summer comfort: In the summer, the typical indoor temperature must be lower than the reference temperature. ▪ The safeguards: the regulation keeps the requirements of the thermal regulation 2000 in terms of ventilation, insulation, heating system, etc. and reinforce them.

Energy saving certificates CEE [45]	
Document type	Certificate
Date	2005
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	Departments of the ministry in charge of energy
Description	Given the obligation of energy suppliers to save energy, they help consumers to reduce their energy bills and in return receive energy saving certificates. The renovation or construction work eligible for obtaining CEE are: insulation, ventilation, heating and regulation and production of domestic hot water.

Energy performance contracts (CPE) [46]	
Document type	Law
Date	2009

Status	In force
Building's type	Existing building
Building's part	All
Building's category	Tertiary building
Steering body	French government
Description	The Energy Performance Contracts - CPE (directive 2006/32) were initiated by the European Union and then implemented into French law with the adoption of the Grenelle Environnement. When carrying out activities to improve energy efficiency, an Energy Performance Contract (CPE) is a contractual arrangement between a project owner and an operator, most typically an energy efficiency services company. The contract isn't about the work itself, but rather the energy savings that will be made as a result of it. The CPE establishes the energy performance goals that must be met. These objectives serve as a measurement reference (energy performance measurement and verification plan) against which the effective improvement in energetic performance may be verified each year following the work (during the CPE's lifetime). The CPE types are: ▪ Supplies and Services, ▪ Works and services, ▪ Global CPE.

Energy performance of buildings Label in Réunion [47]	
Document type	Label
Date	2009
Status	Voluntary
Building's type	All
Building's part	All
Building's category	All
Steering body	La Réunion University
Description	This label defines a set of technical requirements according to the 4 climatic zones of la Réunion related to: ▪ Take into consideration the environment of the building during its design, ▪ Insertion of sun protection, ▪ Promote natural transverse ventilation and identification of natural and mechanical hygienic ventilation requirements, ▪ Promote natural lighting, ▪ Specification of the thermal characteristics of opaque walls and windows, ▪ Identification of the requirements of the technical equipment used (lighting systems, air conditioning, domestic hot water production, etc.).

CE marking – EU regulation No. 305/2011 [48]	
Document type	Regulation
Date	2011
Status	In force
Building's type	All
Building's part	Construction products
Building's category	All
Steering body	Ministry of Ecological Transition
Description	Regulation (EU) No. 305/2011 introduces CE marking in the construction industry with the goal of providing uniform conditions for the marketing of construction products throughout the European Union. When a construction product is covered by a harmonized standard, the manufacturer must apply the CE marking to it and prepare a declaration of performance before putting it on the market.

Thermal regulation 2012 [49]	
Document type	Regulation
Date	2012
Status	In force
Building's type	New buildings
Building's part	All
Building's category	All
Steering body	Ministry of Ecological Transition
Description	The 2012 thermal regulations include 3 performance requirements: ▪ Bioclimatic needs of the building (Bbiomax): Defines the minimum energy efficiency of the building obtained after considering environmental impacts (exposure to the sun, wind, etc.) ▪ Primary energy consumption (Cepmax): It reflects the consumption of heating, air conditioning, lighting, and domestic hot water production equipment. Its value is determined by the geographical location, the altitude, the building use and the average surface area of the dwelling. Its value is 50 kWhEP/m²/year. ▪ Comfort in summer (Ticréf): Thermal regulation 2012 identifies buildings types for which it is possible to ensure a high level of comfort in summer without using an active cooling system. These two categories (CE1 and CE2) are based on the type of occupation and the location (climatic zone, altitude, proximity to noise zones). For these

	buildings, the regulations require that the hottest temperature reached in the premises, during a sequence of 5 very hot summer days, does not exceed a certain threshold. It also includes resource requirements (waterproofing, glazed surface, display of energy consumption, etc.) and high-performance safeguards (treatment of thermal bridges).

Thermal Aeraulic and Acoustic regulations related to hygiene ventilation in Guadeloupe, Martinique, Guyana and la Reunion [50]	
Document type	Regulation
Date	2016
Status	In force
Building's type	New buildings
Building's part	All
Building's category	Residential
Steering body	Ministry of Ecological Transition
Description	Identification of natural and mechanical hygiene ventilation requirements for new buildings. This regulation defines the minimum specifications for natural ventilation for each room in the house and the characteristics of mechanical ventilation, if necessary. It is specific to the residential sector.

Thermal Aeraulic and Acoustic regulations related to natural ventilation of thermal comfort in Guadeloupe, Martinique, Guyana and la Reunion [41]	
Document type	Regulation
Date	2016
Status	In force
Building's type	New buildings
Building's part	Envelop
Building's category	Residential
Steering body	Ministry of Ecological Transition
Description	This regulation is specific to new residential buildings, it concerns the following points: ▪ Identification of natural ventilation requirements for housing. ▪ Specification of ventilation rates and characteristics of openings in the building envelope to provide comfort ventilation.

Thermal Aeraulic and Acoustic regulations related to protection against solar radiation in Guadeloupe, Martinique, Guyana and la Reunion [42]	
Document type	Regulation
Date	2016
Status	In force
Building's type	New buildings
Building's part	Envelop
Building's category	Residential
Steering body	Ministry of Ecological Transition
Description	This regulation is specific to new residential buildings, it concerns the identification of the dimensions and technical characteristics of solar protection and sun visor.

Thermal Aeraulic and Acoustic regulations related to solar domestic hot water production in Guadeloupe, Martinique, Guyana and la Reunion [53]	
Document type	Regulation
Date	2016
Status	In force
Building's type	New building
Building's part	All
Building's category	Residential
Steering body	Ministry of Ecological Transition
Description	This regulation is specific to new residential buildings, it concerns the following points: ▪ Ensure at least 50% of the need for domestic hot water by solar energy, under certain conditions, ▪ Specification of the technical characteristics and dimensions of the solar hot water production system and their installation, ▪ Identification of the technical characteristics of domestic hot water production systems.

Positive Energy and Carbon Reduction label (E + C-) [54]	
Document type	Label
Date	2016
Status	Voluntary
Building's type	New buildings
Building's part	All
Building's category	All
Steering body	Certification bodies

Description	The E + C- label is jointly composed of an Energy level (assessed by the "BEPOS balance sheet" indicator) and a Carbon level (assessed by the "Carbon" indicator). In order to take into account the specificities of the types of buildings, the location and the costs incurred, 4 performance levels are proposed for energy and 2 for carbon. The levels of performance of a new building are defined by: ▪ A level of "Energy" based on the Bilan BEPOS indicator, ▪ A level of "Carbon" based on: - A measure of greenhouse gas emissions over the course of a product's life cycle. - Greenhouse gas emissions indicator from construction products and equipment use.

Existing regulation "on board" [55]	
Document type	Regulation
Date	2017
Status	In force
Building's type	Existing building
Building's part	Envelop
Building's category	All
Steering body	Ministry of Ecological Transition
Description	According to the law on energy transition for green growth, in the event of substantial renovation work, thermal insulation is therefore mandatory according to certain criteria.

Existing thermal regulations by element [55]	
Document type	Regulation
Date	2018
Status	In force
Building's type	Existing building
Building's part	All
Building's category	All
Steering body	ADEME
Description	When a client replaces or installs an insulation element, heating, hot water production, cooling, ventilation, or lighting equipment (this last item only applies to tertiary buildings), it must use products with higher performance than the minimum characteristics specified in the May 3, 2007, order, as amended on January 1, 2018. These requirements pertain to the following: ▪ walls, roofs, and floors with opaque walls,

	▪ walls made of glass, ▪ ventilation, cooling, recooling and heating, ▪ domestic hot water, ▪ lighting.

Global existing thermal regulation [55]	
Document type	Regulation
Date	2018
Status	In force
Building's type	Existing building
Building's part	All
Building's category	All
Steering body	ADEME
Description	Global existing thermal regulation is applicable when the area of the building subject to major renovation exceeds 1000 m². The requirements of this regulation concern: ▪ Energy saving: The building's overall energy consumption for heating, hot water, cooling, auxiliary, and lighting must be lower after renovation than it was before it. In addition, the regulation establishes a maximum consumption value for residential building. The renovated building's energy consumption for heating, cooling, and domestic hot water must be below a certain threshold, which varies depending on the kind of heating and the climate. In comparison to the existing fleet average of 240 kWh/m^2/year, this maximum consumption ranges between 80 and 195 kWh/m^2/year, depending on the circumstance. The renovation should result in a 30% reduction in energy consumption in non-residential buildings as compared to the previous state. ▪ Summer comfort: To reduce occupant's discomfort and air conditioning demand, the renovated building must provide acceptable summer comfort. As a result, the typical indoor temperature in the summer must be lower than a reference temperature. ▪ The safeguards: When a series of components (insulation, ventilation, heating system, etc.) are adjusted by renovation work, minimum performance is required.

Thermal regulation 2020 [56]	
Document type	Regulation
Date	2020
Status	In force
Building's type	New buildings

Building's part	All
Building's category	All
Steering body	Ministry of Ecological Transition
Description	With a few exceptions, all new structures submitted for a construction permit after the end of 2020 must have a primary energy consumption lower than the quantity of renewable energy produced in the building. The second goal is to integrate renewable energy production (PER) into the habitat, such as by installing photovoltaic solar panels, a Canadian well, a wood fire, or a thermodynamic balloon. To generate more energy than the building uses. We use then the term "positive building" (BEPOS) to describe a structure that produces more energy than it consumes.

The energy performance diagnosis (DPE) is part of a European-level energy strategy aimed at reducing building energy consumption and limiting greenhouse gas emissions.

The DPE has been modified to be more dependable, readable, and to take climate change into consideration. The new DPE will take effect on July 1, 2021, and will last for ten years.

Diagnostic de performance énergétique (DPE) [57]	
Document type	Regulation
Date	2021
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	ADEME
Description	The energy performance diagnosis (DPE) offers information about a home or building's energy performance by evaluating its energy consumption and greenhouse gas emissions, which may be seen on the energy label and the climate label. Two labels with seven classifications from A to G (A equating to the best performance, G relating to the worst) make it easier to read the DPE: ▪ The energy label to find out how much energy is used in the first place, ▪ To determine the amount of greenhouse gases emitted, consult the climate label. The DPE details the structure or habitation (surface, orientation, walls, windows, materials, and so on), as well as the heating, domestic hot water, cooling, and ventilation equipment and their operating parameters. It reflects either the quantity of energy spent (based on bills) or the predicted energy consumption for a

	standardized use of the building or home, depending on the circumstance (with a calculation method). The DPE is issued when a building or part of a structure is sold, when a residential building is rented, and when a new building is constructed.

Du to the importance of energy consumption in the building sector in France, the government has taken several steps to improve energy efficiency, mainly:

- Regulate the construction and renovation sector by imposing a level of energy performance to be achieved,
- Set requirements for reducing energy consumption in tertiary and residential buildings,
- Offer measures and financial aid to build or renovate efficiently,
- Encourage the generalization of positive and low-carbon buildings.

In this perspective, the French regulatory infrastructure has undergone continuous development and adaptation. Indeed, each thermal regulation is preceded by a label making it possible to apprehend its new requirements. Each thermal regulation tends toward the achievement of a more advanced energy saving objective and to increase the rate of greenhouse gas emissions to be avoided. The main purpose is to be able to set up positive energy buildings consuming the minimum possible energy.

The French regulatory infrastructure related to energy efficiency in buildings is comprehensive and includes:

- New buildings,
- Existing and renovated buildings,
- Energy equipment.

Climatic aspects are visibly taken into consideration when drafting laws and regulations in France. Indeed, specific regulations for overseas territories have been drawn up. However, the future climate state is not included.

The promotion of bioclimatic buildings is also of great importance. Indeed, the bioclimatic aspects are integrated in the thermal regulations. Therefore, any building complying with regulatory requirements implicitly respects the technical measures of bioclimatic buildings.

Financial aid is offered for individuals as well as social landlords to support energy renovation. Individuals can take use of the MaPrimeRénov'aid tax credit for energy transition, bonuses provided for Energy Saving Certificates, National Housing Agency aid, Action aid Housing, and a lower VAT rate. They can finance the rest with the zero-interest eco-loan. Local assistance is also available, such as bonuses provided by the Commission for Energy Regulation in Corsica and elsewhere.

There are, however, obstacles delaying the achievement of national targets for reducing energy consumption and greenhouse gas emissions, according to "Les avis du CESE" report [58]:

- The lack of trained professionals,

- The lack of human resources at local authorities for the application of legal texts,
- The need for specific financial assistance adapted to the renovation of existing buildings,
- The complexity of procedures and steps in the application of laws.

The main recommendations to further develop energy efficiency in buildings are:

- Facilitate the commitment of all actors and stakeholders in the sector by allocating the region's material and human resources allowing them to participate effectively in the energy transition,
- Facilitate the application of laws by streamlining the procedures to be followed,
- Promote and create at national and regional level specialized vocational training aimed at developing skills in terms of energy efficiency in buildings.

2.2. ECOWAS / Pan African Level

- **North African Countries**

Final energy consumption in South-Med countries increased from 113 Mtoe in 1990 to 248 Mtoe in 2013, with a conservative estimate of 606 Mtoe by 2040. Buildings would account for more than 20% of overall consumption, with 50 million new homes expected to be built by 2040. In an energy transition scenario, new buildings would need to save 40% of their energy and existing buildings would need to save 10% to 15% of their energy, with a focus on the residential sector.

According to a study conducted across several Mediterranean countries, heating accounted for less than 5% of household energy use in Morocco in 2010, compared to 20% in Tunisia and 30% in Algeria (against 70 percent in France for example). In these three countries, electrical appliances and air conditioning are becoming more prevalent: between 2000 and 2010, the share of households using air conditioning increased from near zero to around 15 percent in Morocco and Tunisia, and from 8 percent to around 15 percent in Algeria. As a result, residential electricity consumption soared dramatically [59].

The rapid economic and demographic growths in the region, the rapid urban developments and high demand for new constructions are the main causes of the observed increase in energy consumption. Hence the need and necessity for the development of the energy efficiency in the building sector.

2.2.1 Morocco

Morocco is currently undergoing significant economic and social improvement as it transitions to green development. Morocco adopted a National Energy Strategy in 2009, to improve energy supply security and availability, as well as to increase general access to energy at reasonable prices. In that sense, Moroccan authorities have promoted an EE policy aimed at clarifying the relationships between administrations and operators. The goals of this EE policy are to establish an institutionalized public management system for EE issues, as well as a suitable legislative and regulatory framework, and to promote norms and standards. Presented below are factsheets about the current legislation on EE in buildings in Morocco.

Law 47-09 on Energy Efficiency	
Document type	Law
Date	2009
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	Ministry of Energy, Mines and Environment Ministry of Industry, Commerce, Green and Digital Economy, AMEE
Technical requirements	Law 47-09, or "Energy Efficiency Law," aims to increase energy efficiency in the use of energy sources, avoid waste, reduce energy costs in the national economy and promote sustainable development. The law includes a series of measures, such as mandatory energy audits, minimum energy performance standards for home appliances and preferential tariffs (known as peak tariffs) for industries that voluntarily shift their energy consumption away from peak periods. This law establishes the minimum energy performance criteria for household appliances and electrical equipment powered by natural gas, liquid or gaseous oil products, coal and renewable energies. It carries out mandatory energy audits for companies and institutions for the production, transmission and distribution of energy, as well as conducting an energy impact study for new constructions and urban projects. It defines the role of energy services and facilities and establishes technical control [60].

Moroccan Standard NM 14.2.300 on Energy labelling of electrical products and appliances	
Document type	Standard
Date	2017
Status	In force
Building's type	All
Building's part	Appliances
Building's category	All
Steering body	IMANOR, AMEE
Technical requirements	Under the standard, appliances requiring mandatory labelling are cooling appliances (refrigerators, freezers and air conditioners), cooking appliances (electric ovens), cleaning appliances (dishwashers, washing machines and clothes dryers), household electric lamps (incandescent and fluorescent lamps with/without integrated ballast), vacuum appliances and TVs.

	The standard was introduced as a voluntary measure in 2010 but was made mandatory in 2011 under the Ministry of Energy and Mines Order 2148-11 (July 2011) [61].

Decree n. 2-13-874 on Thermal regulation of buildings	
Document type	Decree
Date	2014
Status	In force
Building's type	All
Building's part	Envelope
Building's category	All
Steering body	AMEE, Ministry of Energy, Mines and Environment, Ministry of Interior, Ministry of Urbanism and Housing,
Technical requirements	The Thermal Regulation for Construction in Morocco was approved and enforced in 2014 by the publication of Decree 2-13-874. Thermal regulation concerns only the building envelope and new construction and covers both the housing and service sector buildings. The regulation divides Morocco into six climatic zones and uses two approaches. A performance-based approach, where levels are expressed in terms of annual heating and cooling requirements, in kWh/m²/year, in relation to an internal reference temperature. The second approach is termed prescriptive and complements the first. Levels are expressed, for each building type and climatic zoning, as the maximum heat transfer coefficients (U in W/(m·K)) of walls, roof, low floors and as windows solar factor (SF), depending on the ratio of the glazed surface to the outside walls surface [62].

Decree n. 2-17-746 on Mandatory energy audits and energy audit organisations	
Document type	Decree
Date	2019
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	AMEE, Ministry of Energy, Mines and Environment Ministry of Industry, Commerce, Green and Digital Economy
Technical requirements	Energy audits are mandatory for consumers whose energy consumption (toe) is higher than: ▪ 1500 toe per year for enterprises and companies belonging to the industry sector, including the energy generators. ▪ 500 toe per year for the tertiary sector, companies and enterprises of the transport sector and energy distribution sector.

	Consumers who carry out their activities under a certified energy management system are exempt from this obligation. The mandatory energy audit includes all activities, industrial procedures, buildings and vehicles used by the company or company analyzed. The companies covered by this decree must communicate annually to the Moroccan Agency for Energy Efficiency all information related to their energy consumption. Mandatory energy audits must be carried out every 5 years. The Moroccan Agency for Energy Efficiency is in charge of creating a database with all the data collected through these audits. Mandatory energy audits must be performed by an organization approved by the energy authority. Section 3 of this decree specifies the requirements for certification of energy audit organizations. Consumers are required to report annually to the energy authority a report on the implementation of their energy efficiency plan [63].

MEPS for Air Conditioners	
Document type	Standard
Date	2018
Status	In force
Building's type	All
Building's part	Appliances
Building's category	All
Steering body	Ministry of Energy, Mines and Environment Ministry of Industry, Commerce, Green and Digital Economy AMEE
Technical requirements	Morocco adopted Air Conditioners Minimum Energy Performance Standards (MEPS) in June 2018 Air-cooled air conditioners: 1) Split and Multi-split Air Conditioners ○ cooling EER > 2.8 ○ heating COP > 3.2 2) Monobloc Air Conditioners ○ cooling EER > 3.1 ○ heating COP > 3.2 Water-cooled air conditioners: • Split and Multi-split Air Conditioners ○ cooling EER> 2.6 ○ heating COP> 3.0 • Monobloc Air Conditioners ○ cooling EER> 3.8 ○ heating COP> 3.0 EER= Energy efficiency ration COP= coefficient of performance

In the Morocco case, some barriers to the fully implementation and development of EE measures are:

- Lack of an integrated approach for alternative energy deployment
- Lack of information and data is still hindering the access of different social segments and utilities to this green knowledge, which is urgently required for answering different issues of EE and RE in Morocco.
- Innovative financial schemes must be implemented to support the deployment of EE and RE technologies
- Lack of R&D, specifically concerning EE and RE.

The Moroccan building code has a two-pronged approach which deals with passive and the bioclimatic regulations. The first one deals with setting minimum R values for each section of the envelope regardless of orientation ventilation, etc. The second approach, which only applies when a building contains over 45% glazing takes into consideration external temperatures, natural ventilation, and orientation. Fixed values on minimum energy needs are to be met through passive techniques to achieve compliance. These fixed values were fixed at the time (2014) and have not been updated to take account of variation in climate.
MEPS are being introduced to account for new technologies and HVAC equipment to control the active equipment's performance. Given that there are no new technologies incorporated in the building codes, they neither hinder nor foster the current thermal regulations.

2.2.2 Tunisia

The building sector is one of Tunisia's most energy-intensive segments. Consumption in this area continues to rise in order to meet various daily needs such as heating, cooling, domestic hot water, ventilation, lighting, cooking, and food storage. Indeed, the sum of this consumption in Tunisia accounts for 27% of total energy consumption [64], a figure that is expected to rise in the coming year. However, the building sector has great potential for energy savings, reaching 56% by 2030 [64].

To achieve this goal, ANME's intervention in this sector spans all phases of building use, from design to operation, and employs a variety of tools, including regulatory, normative, and incentive. All these interventions can be classified into two types: passive EE, which includes all actions aimed at improving a building's intrinsic qualities, and active EE, which includes all actions aimed at optimizing energy systems and uses.

The evolution of the regulatory framework in the field of EE in buildings in Tunisia is as follows:

Decree number 8 of 14 December 1985 relating to energy saving [65]	
Document type	Decree
Date	1985
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	Ministry of Industry, Energy and Small and Medium Enterprises
Technical requirements	▪ Creation of a public agency benefiting from civil autonomy and financial independence called the energy management agency.

	▪ Definition of the missions of the said agency. ▪ Identification of the conditions for the rationalization of energy use regarding heating and air conditioning devices and thermal insulation of equipment. ▪ Identification of the advantages and sanctions of energy consumers.

Law n 2004-72 of August 2, 2004, relating to energy management. Law No. 2009-7 of February 9, 2009 [66] [67]	
Document type	Law
Date	2004–2009
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	Ministry of Industry, Energy and Small and Medium Enterprises
Technical requirements	This law defines the energy management and places it as a national priority. It identifies energy management actions such as compulsory and periodic energy audits, cogeneration, labelling of materials, appliances and household appliances, thermal regulations for new buildings, promotion of renewable energies, etc. It also defines establishments of energy service and their roles. According to this law, the national agency for energy management is created and its missions are defined. The advantages and sanctions linked to energy management are also explained.

Decree of 4 December 2004 relating to the specifications governing the operation of energy service companies [68] [69]	
Document type	Decree
Date	2004–2005
Status	In force
Building's type	All
Building's part	All
Building's category	Existing buildings
Steering body	Ministry of Industry, Energy and Small and Medium Enterprises
Technical requirements	The specifications define the conditions and missions to which energy service companies must respond. This decree also defines the different contents of contracts between the energy service establishment and the energy consumer benefiting from the energy audit.

Thermal regulations for new buildings [70] [71]	
Document type	Regulation
Date	2008–2009
Status	In force

Building's type	All
Building's part	Envelop
Building's category	New buildings
Steering body	Ministry of Industry, Energy and Small and Medium Enterprises. Ministry of Equipment, Housing and Regional Planning.
Technical requirements	The thermal regulations for new buildings define a climatic zoning which divides Tunisia into 3 climatic zones. In each zone, and according to the type of building, the regulations set the thermal requirements to be respected. These thermal requirements are defined according to two approaches depending on the surface of the building and its overall rate of windows bay in: A prescriptive approach which fixes the thermal transmission coefficients of roofs, exterior walls and windows bay. A performance approach which consists in fixing the annual calorific and cooling energy needs. This regulation came into force after the publication of the decree of July 23, 2008, relating to buildings for office use and the like and the decree of June 1, 2009, relating to residential buildings.

Energy audit [72] [73]	
Document type	Decree No. 2144 of September 2, 2004 (amended and supplemented by Decree No. 2269 of July 31, 2009).
Date	2004–2009
Status	In force
Building's type	All
Building's part	All
Building's category	Existing buildings
Steering body	The National Agency for Energy Management (ANME)
Technical requirements	▪ Perform a diagnosis of energy consumption within the building, ▪ Evaluate the building's energy performance level, ▪ Analyse the causes of energy consumption drifts in the building, ▪ Identify the energy saving potentials in the building, ▪ Propose an action plan to reduce the building's energy consumption and improve its energy performance, ▪ Energy Audit is compulsory for any building in the tertiary sector whose total annual primary energy consumption exceeds or is equivalent to 500 toes, Periodicity: All establishments are required to carry out an EA every 5 years.

Energy audit on plan [74]	
Document type	Order of the Minister of Industry, Energy and Small and Medium-Sized Enterprises of June 11, 2007.
Date	2007
Status	In force
Building's type	All
Building's part	All
Building's category	New buildings
Steering body	The National Agency for Energy Management (ANME)
Technical requirements	▪ Carry out a diagnostic on the energy performance plan of the building project throughout the design studies phase, ▪ Identify the potential for improving the energy performance of the building project, ▪ Propose an action plan for improving the energy performance of the building project, ▪ Monitor the implementation of the action plan to improve the energy performance of the building project. ▪ Energy audit on plan is compulsory for any building project in the residential and tertiary sectors where the total annual forecast consumption of primary energy exceeds or is equivalent to 200 toes.

Label Eco-Bat	
Document type	Label
Date	—
Status	Voluntary
Building's type	All
Building's part	All
Building's category	All
Steering body	The National Agency for Energy Management (ANME)
Technical requirements	Classification of buildings into 3 categories: gold, silver and bronze according to criteria and energy efficiency indicators on the passive and active side.

Decree of October 24, 2005, related to Certification and MEPS for refrigerators [75] [76]	
Document type	Certification
Date	Certification: 2004 MEPS: 2005–2008
Status	In force
Building's type	Residential buildings
Building's part	Appliances

Building's category	All
Steering body	Ministry of Industry, Energy and Small and Medium Enterprises
Technical requirements	Progressive ban on the marketing of CPE devices between 4 and 8: 2006: Classes 7 and 8, 2007: Classes 5 and 6, 2009: Class 4.

Decree of 21 April 2009 of certification for air conditioners [77]	
Document type	Certification
Date	Certification: 2009
Status	In force
Building's type	All
Building's part	Appliances
Building's category	All
Steering body	Ministry of Industry, Energy and Small and Medium Enterprises
Technical requirements	The provisions of this decision apply to room air conditioners of all types whose cooling capacity is less than 12 kW. This decree defines the method for calculating the energy classes of air conditioners according to their type as well as the requirements of producers and the content of the energy label.

Decree of 30 June 2009 of MEPS for air conditioners [78] **Decree of 12 August 2011 of MEPS for air conditioners [79]**	
Document type	MEPS
Date	MEPS: 2010–2011
Status	In force
Building's type	All
Building's part	Appliances
Building's category	All
Steering body	Ministry of Industry, Energy and Small and Medium Enterprises
Technical requirements	The provisions of this decision apply to room air conditioners of all types whose cooling capacity is less than 12 kW. Progressive ban on the marketing of CPE devices between 4 and 8: 2010: Classes 6, 7 and 8, 2011: Classes 5, 2012: Class 4.

Decree of 18 August 2010 related to phasing out of incandescent lamps used in buildings [80]	
Document type	Decree

Date	2010
Status	In force
Building's type	All
Building's part	Appliances
Building's category	All
Steering body	Ministry of Industry, Energy and Small and Medium Enterprises
Technical requirements	Prohibition of sale of incandescence lamps for residential use with a power exceeding 100 W and a voltage greater than or equal to 100 Volt.

Tunisia is a pioneer country in the field of EE in buildings. Indeed, this country has been keen to put in place a powerful regulatory framework since the 1980s accompanied by national programs to promote EE in buildings such as:

- Energy audits in buildings,
- Promo-isol program,
- LBC lamps promotion program,
- Promo-frigo program,
- Prosol program,
- Prosol- Elec program,
- Promotion of natural gas air conditioning.

The Tunisian government established an interministerial committee in June 2019 with the task of developing a roadmap to make the display of thermal and energy performance of new buildings mandatory when renting or selling. This measure should first affect the tertiary sector, then the residential sector.

Household appliance certification is also in the works, and will include, in addition to refrigerators and air conditioners, lamps and lighting, washing and drying machines, dishwashers, ovens, irons, and audio-visual equipment.

The requirements of Tunisian thermal regulations differ from one climatic zone to another, considering its climatic data, and implicitly integrate the requirements of bioclimatic buildings. However, future climate data is not involved in the development of these laws/certifications. In addition to the technical requirements applicable to energy equipment, the energy performance of the building envelope is promoted through a set of Tunisian programs and labels such as the Promoisol program. Therefore, the passive part of the building is also taken into consideration in Tunisia.

The development of EE in buildings in Tunisia is hampered by a lack of human resources specialized in EE, which creates a barrier to regulatory text implementation. This deficiency is most noticeable in regional administrations and municipalities.

According to the ANME's 2013 report on the summary of the 2013–2020 action plan on the rational use of energy [55], flaws in the regulatory framework were discovered specialty du to:

According to the ANME's 2013 report on the summary of the 2013–2020 action plan on the rational use of energy flaws in the regulatory framework [81] were discovered specially du to:

- Lack of regulatory text review to ensure consistency with the evolution of EE activities,

- Regulatory enforcement issues.

Therefore, various recommendations, according to the Study Report on National Policies and proposals for actions in favour of sustainable energy development in planning and local management in Tunisia [82], are proposed to overcome these obstacles, such as:

General recommendations:

- Continuous enhancement of the regulatory framework governing EE activities,
- The timing synchronization of the publication of laws and decrees,
- Creation of a Sustainable Energy Information Point at municipalities, with the goal of raising awareness and communicating about sustainable energy.
- Strengthening the modalities of control of the text's application,
- Creating an Energy Control Committee at the municipal level, with the main tasks of defining a local action plan, validating EE projects within the municipality, making necessary arrangements for the removal of constraints that may arise during project implementation and monitoring project completion.

Specific recommendations related to:

- Thermal regulation of buildings:
  - → Increase the importance given to EE when issuing building permits for the tertiary sector and collective buildings in the residential sector.
- Rely on EE experts and specialists to assist municipalities with energy studies and monitoring the implementation of EE actions suggested in the audits on plan and energy studies that served as the basis for granting the authorization to construct buildings.
- Certification of household appliances:
  - → Emphasize household appliance certification control campaigns.
- Energy audit on plan and prior consultation:
  - → Each municipality will carry out actions to raise awareness of the requirement to conduct an energy audit on plan or prior consultation basis for any new or expanded tertiary establishment or extension within its territorial boundaries.

2.2.3 Egypt

Egypt is known for its arid and hot climate, making its cooling needs continuously expanding, especially given the large population of the country. To decrease its energy consumption, the country developed building codes and standards for appliances.

Energy Efficiency Code for Buildings (EPC 306-2005) First Part: Residential Buildings (code n° 306/1)	
Document type	Regulation
Date	2006
Status	In force

Building's type	Residential
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Housing Utilities and Urban Development
Technical requirements	Residential BEEC indicates minimum design and application requirements for new buildings, residential parts of new multi-use structures, new additions to existing buildings, and new devices and systems installed to residential buildings. The residential code is divided into ten chapters. They indicate energy efficiency strategies and basics to provide thermal comfort. It introduces a common understanding of the BEEC concepts, specifies general application requirements, and identifies minimum and maxim energy requirements for the following elements [83]: 1. Building envelope. 2. Ventilation and thermal comfort. 3. HVAC systems and water heating systems. 4. Natural and artificial lighting. 5. Electric loads. 6. Building total consumption.

Energy Efficiency Code for Buildings (EPC 306-2005) Second Part: Commercial Buildings (code n° 306/2)	
Document type	Regulation
Date	2009
Status	In force
Building's type	Commercial
Building's part	Envelope and appliances
Building's category	All
Steering body	Ministry of Housing Utilities and Urban Development
Technical requirements	The commercial energy code specifies the minimum building requirements to improve thermal and visual comfort in non-air-conditioned buildings, as well as the minimum energy efficiency requirements in air-conditioned buildings. This code provides minimum performance standards for building windows and openings, natural ventilation, ventilation and air conditioning equipment, natural and artificial lighting and electrical energy. [84].

Non-ducted air conditioners and heat pumps- Testing and rating for performance (standard 4814/2018)	
Document type	Standard
Date	2018

Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	The minimum energy performance standard for non-ducted air conditioners and heat pumps are established by this standard. Based on ISO 5151/2017, the standards were developed. The standard was mandated by decision 589–2019/102 [85].

Air Conditioners Energy Efficiency Standard No. 3795-1/2016	
Document type	Standard
Date	2016
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard establishes label requirements for room air conditioners (both window and split) with fixed capacity and fixed compressor. It was adopted through Decision 1098\2016 [86].

Building environment design – guidelines to assess energy efficiency of new buildings No 8029/2016	
Document type	Standard
Date	2016
Status	In force, not mandatory
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard is concerned with giving instructions related to energy efficiency in buildings as stated in the Egyptian standard 6475/2008 and the corresponding international standard to which the purpose of this standard is to assist designers and participants in the collection and supply of useful data [87].

Energy efficiency of household and similar electrical appliances measurement and calculation methods for energy consumption of refrigerators, refrigerator-freezers, and freezers n° 3794/2018	
Document type	Standard
Date	2018
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard applies to household refrigerators, freezers and the like, which are operated using AC power at a frequency of 50 Hz and a voltage of no more than 250 volts for single-sided devices and 480 volts for other devices [88].

Energy efficiency of household electrical appliances methods for measuring and calculating energy efficiency of domestic ovens n° 3794/2018	
Document type	Standard
Date	2017
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard specifies the requirements for energy efficiency for electric household ovens, which aim at rationalizing electrical energy consumption and improving environmental conditions by limiting the emission of harmful gases to the environment resulting from the increased use of energy [89].

Energy efficiency of household electrical appliances methods for measuring and calculating energy efficiency of electric instantaneous water n° 8187/2018	
Document type	Standard
Date	2018
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality

Technical requirements	This standard specifies requirements for energy efficiency labelling for electric household instant water heaters with thermal output power less than or equal to 70 kW [90].

Energy efficiency of household electrical appliances methods for measuring and calculating energy efficiency of vacuum cleaners n° 8057/2017	
Document type	Standard
Date	2017
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard specifies requirements for the energy efficiency of household vacuum cleaners, which aim at rationalizing electrical energy consumption and improving environmental conditions by reducing the emission of harmful gases to the environment resulting from the increased use of energy. It is based on Regulation (EU) No 665/2013 - IEC 62885-2/2016 [91].

Energy efficiency label for televisions and displays n° 7993/2018	
Document type	Standard
Date	2018
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard specifies requirements for energy efficiency labelling and precautions for additional information for televisions and displays. It is based on EU 1062/2010 [92].

Energy efficiency requirements for electrical lamps and luminaries n° 7823/2020	
Document type	Standard
Date	2020
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All

Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard establishes requirement for labelling and providing supplementary product information and energy efficiency requirements for electrical lamps. It is based on commission regulation no 874/2012 and commission regulation no 1194/2012 [93].

Energy efficiency of household electrical appliances methods for measuring and calculating energy efficiency of electric circulating air fans n° 7821/2014	
Document type	Standard
Date	2014
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard applies to the following types of fans, which are directly driven by an electric motor and are designed for use in single-sided AC circuits at a frequency of 50 Hz, with the voltage of either of them not exceeding 250 volts. It is based on IEC 60879, Performance and construction of electric circulating fans and regulators [94].

Energy efficiency of household and similar electrical appliances methods for measuring and calculating energy consumption of residential dishwashers n° 7820/2014	
Document type	Standard
Date	2014
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard applies to household electric dishwashers that are operated by alternating current through a single-face electrical supply, so that the rated voltage does not exceed 250 volts, and they are fed with cold water, and contain an electric heating device. It is based on IEC60436:2004+A1:2009+A2:2012 [95].

Energy efficiency of household and similar electrical appliances methods for measuring and calculation energy consumption of washing machines n° 4100/2006	
Document type	Standard
Date	2006
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This standard aims to rationalize electrical energy consumption, rationalize water consumption, and improve environmental conditions, by limiting the emission of harmful gases to the environment resulting from the increased use of electrical energy, in addition to protecting the consumer from high-efficiency products. It is based on IEC 60465/2003 + cor1/2005 and IEC-60335-1/2001-Amd 1 [96].

Energy efficiency label requirements for air conditioner part 5: - fixed capacity ducted room air conditioner with fixed speed compressor n° 3795-5/2018	
Document type	Standard
Date	2018
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This part of the standard applies to a split fixed capacity ducted room air conditioner equipped with a constant speed compressor, with a rated cooling capacity of less than 20 kW (68,300 bhp/hr) for a separate AC [97].

Energy efficiency label requirements for air conditioner part 2: variable capacity room air conditioner (window - split) with variable speed compressor n° 3795-2/2017	
Document type	Standard
Date	2017
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All

Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This part of the standard applies to room air conditioner operating without variable capacity ductwork and equipped with a variable speed compressor, with a rated cooling capacity not exceeding 10.55 K [98].

Energy efficiency label requirements for air conditioner's part 1: room air conditioner (window – split) with fixed capacity & fixed compressor n° 3795-1/2016	
Document type	Standard
Date	2016
Status	In force
Building's type	All
Building's part	Appliance
Building's category	All
Steering body	Egyptian Organization for Standards & Quality
Technical requirements	This part of the standard applies to fixed capacity room air conditioners without ducts equipped with a constant speed compressor [99].

Egypt's buildings codes, which covers both the building envelope and appliances, constitutes an encouraging framework for bioclimatic buildings and usage of passive techniques. The codes take into account the climatic difference across Egypt, putting specific requirements for each of the Egyptian climatic zones. The codes cover new constructions and newly built parts of existing constructions. They also cover existing buildings that intend to renovate fractions of their envelopes or appliances. However, neither the codes nor the standards consider the future climatic changes.

Today, despite the existence of a building code in Egypt, enforcement and compliance checks of residential buildings are facing a number of challenges [100]:

1. Lack of strict control and supervision leading to informality and non-compliance with the code.
2. Municipal engineers may not be able to implement and comply with the Building Code or evaluate certain technologies with the required skills and information.
3. Architects and engineers lack the necessary skills to implement the Building Code.
4. For most income groups, electricity is subsidized so there are few incentives for consumers to adopt more energy efficient behaviours.
5. Lack of shared awareness.
6. Lack of financial incentives to invest in strategies for EE.
7. Long reimbursement period for efficient devices (i.e., solar panels).

8. Low-income households cannot invest in EE measures.
9. Lack of low-income groups funding sources (e.g., loans, funds, etc.).
10. The Egyptian market is not ready and there is a lack of economically convenient competitive technology.
11. Absence of a system for monitoring and preventing ineffective machinery on the market.
12. Absence of a program of awareness targeting designers as well as consumers.

2.2.4 Libya

Development of policies and measures needs tremendous efforts and work that should be assigned to specialists in committees and working groups. Renewable Energy Authority of Libya (REAoL) is a national authority that was dispersed the task of providing and employment of energy efficiency in the country. They had prepared a National Energy Efficiency Action Plan (NEEAP). In doing so, they reviewed the world practices of energy efficiency trying to come up with best of these practices to implement it in Libya in a proper way. They determined and defined all barriers that are facing energy efficiency. They were also assigned to propose the required laws, regulations and incentives to be approved by the Libyan government as well as perform tasks of raising public awareness and acceptance of energy efficiency programs that would be implemented. [101]

Current enabling policies (including: RE; EE; private sector participation; & PPPs facilitation) (list 5 max) most critical ones	Renewable energy roadmap to 2030 • National Energy Efficiency Action Plan (NEEAP)
Current enabling laws/pieces of legislation (including: RE; EE. private sector participation; & PPPs facilitation) – including electricity/grid codes & oil codes (5 max or yes/no) most critical ones	• Prime Ministerial Decision of 8 September 2009 establishing Energy Council • Draft Electricity Bill

ENERGY EFFICIENCY Code for buildings	
Document type	Standard
Date	2016
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	Renewable Energy Authority of Libya REAoL
Technical requirements	▪ Cooling load – Envelope optimization: aim 60 kWh/m^2. ▪ Hot water production: SHW system aim of 82% hot water production. ▪ PV system potential of 15700 kWh per year

	▪ Efficiency AC: 30% savings from prior systems

The potential for energy efficiency in buildings is large both in new and in existing buildings. Over time the energy efficiency in buildings can be reduced by more than 60% alone with measures, which are feasible already today [102].

However, the implementation of the EE measures phases several technical, regulatory, financial obstacles. The meetMED EE in building report identified these main issues as:

- High political, security, and governance risks,
- National EE regulatory and institutional frameworks are lacking,
- Low energy and electricity prices, particularly in the residential sector,
- Absence of designated national institution in charge of energy efficiency,
- Lack of a national strategy as well as a medium- and long-term NEEAP.
- There are few detailed and in-depth studies that emphasize the impact of energy efficiency in buildings and assist decision makers in implementing energy efficiency programs. In addition, national data and information are unavailable,
- There is no energy code for buildings,
- There are no dedicated EE financing structures or incentives in place,
- There is a scarcity of EE technology and information, as well as national experience and knowledge. [103]

For all these reasons, the development of EE in Libya requires:

- To create institutions responsible for the development, application, monitoring and verification of the implementation of EE projects,
- To develop codes, laws, standards and regulations focused on EE in buildings, introducing new technologies and bioclimatic aspects of construction,
- To enforce the developed codes and regulations,
- To develop trainings for professionals in the field,
- To establish a database related to energy building consumptions and indicators,
- To raise citizens' awareness of the importance of EE in buildings through demonstrative projects,
- The allocation of incentives and financial aid for the promotion of EE in the country.

2.2.5 Algeria

In Algeria, the building sector is one of the major consumers of energy. Excluding hydrocarbons, it absorbs 42% of total final energy consumption, of which 35% for residential and 7% for tertiary energy. Transportation ranks second (35%) and the industry is third on this podium with 16%. The building is therefore one of the priority targets of the Algerian state's action on energy efficiency (EE). Algeria has also developed several regulatory mechanisms aimed at promoting energy efficiency in the building sector. They specify the requirements for safety, stability, hygiene, and the level of comfort compatible with social and environmental requirements both in terms of construction and operation of the building. Based on the analysis of the consumption of new housing carried out in 1995, the Ministry of Housing and Urban Planning developed through the National Center for Integrated Studies and Research of the building (CNERIB) regulatory technical documents (DTR) in 1997. These DTR were subsequently approved by the Ministry of Energy and Mines and were the subject, in 2000, of

a decree on the thermal regulations in new buildings in application of the 1999 law on energy control. [104]

These DTRs, which only apply to buildings, mention the regulatory requirements that their envelopes must meet, namely:

DTR C 3-2 rules for calculating winter heat loss	
Document type	Decree
Date	2000
Status	In force
Building's type	Residential buildings.
Building's part	Appliances
Building's category	All
Steering body	Ministry of Energy and Industry APRUE
Technical requirements	It aims to limit the energy consumption of space heating by calculating thermal losses;

DTR C 3–4 rules for calculating summer heat intakes	
Document type	Decree
Date	2000
Status	In force
Building's type	Residential buildings.
Building's part	Appliances
Building's category	All
Steering body	Ministry of Energy and Industry, APRUE
Technical requirements	It aims to limit the energy consumption of air conditioning in the premises.

DTR C 3–31 related to natural ventilation	
Document type	Decree
Date	2000
Status	In force
Building's type	Residential buildings
Building's part	All
Building's category	All
Steering body	Ministry of Energy and Industry APRUE
Technical requirements	It provides the general principles to be adopted when designing natural ventilation facilities.

DTR E 4.4 "Thermal insulation and waterproofing of ribbed steel sheet roofs"	
Document type	Decree
Date	2004
Status	In force
Building's type	Residential buildings.
Building's part	All
Building's category	All
Steering body	Ministry of Energy and Industry APRUE
Technical requirements	It provides the general principles to be adopted in the design of roofs

DTR C3-2/4: Thermal regulation of the building	
Document type	Decree
Date	2016
Status	In force
Building's type	Residential and tertiary
Building's part	Envelope, heating and cooling
Building's category	New buildings
Steering body	Departments of Energy and Industry, APRUE, Ministry of Housing and urbanization
Technical requirements	The application of this thermal regulation must inevitably lead to the thermal insulation of new buildings, with the aim of reducing energy consumption related to heating and air conditioning.

The purpose of this regulation is to strengthen the overall energy performance of the building. Its application makes it possible to reduce the calorific needs of new homes for heating and air conditioning. It has entered into force since 2005, but it faces many difficulties of effective implementation, linked to the absence of a control and monitoring body mandated for this purpose. [105][106].

According to meetMED EE in building report, Algeria confronts several problems in terms of implementation, enforcement, and monitoring EE measures, as well as the availability of and accessibility to technical solutions. The principal obstacles identified by the report are:

- Low energy prices that reduce the impact of incentives,
- Thermal regulation is not applied and controlled,
- Political priority is placed first to easing the housing crisis,
- A deficit of trained and skilled professionals,
- A poor institutional framework,

Algeria must overcome these obstacles to enhance the energy efficiency of its building stock, in order to do develop this field, the principal recommendations are:

- Strengthening the institutional framework,
- Reforming energy prices,
- Reform of energy costs,
- Enforcement of regulations,
- Public awareness campaigns.

Algeria has already established its energy efficiency building code without implementing it nor identifying the responsible entity for their implementation. This code still voluntary only applied for new non-residential buildings. It contains requirements related to lighting, cooling and heating space. Although the existence of this code, it needs to be updated to include new technological specifications and future climate change [103].

- **West African Countries**

Energy poverty, with its severe economic and societal effects, will continue to be a problem for West Africa in 2030 unless significant investment is made. With a population of over 340 million people, the region has one of the lowest rates of modern power usage in the world.

In July 2010, the ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE) was founded, demonstrating ECOWAS member states' commitment to improving energy access, energy security, climate change mitigation, and emissions reduction. ECREEE is a regional renewable energy and energy efficiency (RE&EE) promotion agency that has received international prominence (ECREEE, 2014).

The agency has several activities, mainly: policy elaboration, capacity building, resource evaluation, knowledge management, and investment promotion.

ECOWAS member states have recognized that increased usage of renewable energy, as well as increased energy efficiency, will be required to meet targets for energy access and security. As a result, the ECOWAS energy ministers adopted regional policy on renewable energy and energy efficiency in October 2012. These policies are intended to address the region's energy problems and challenges [107].

2.2.6 Ghana

Ghana experienced strong economic growth in the 1980s and 1990s, which resulted in a significant increase in energy demand. Ghana's electricity supply capacity was unable to keep up with the country's rapid growth in demand. Appliance energy efficiency policies have become an important part of the solution to this national crisis [108]. These policies include MEPS for air conditioners and refrigerators in 2015, making Ghana the first country in Sub-Saharan Africa to adopt them [109].

Ghana Building Code GS1207: 2018	
Document type	Regulation
Date	2018
Status	In force
Building's type	All
Building's part	All

Building's category	All
Steering body	Ghana Standards Authority
Technical requirements	The Ghana Building Code (GhBC) establishes minimum requirements for buildings using prescriptive and performance-related provisions. It is founded on broad-based principles that make possible the use of new materials and new buildings designs. The provision of the Code applies to all operations related to the construction, maintenance or removal of building structures, and include chapters on energy and water efficiency and on green building requirements for the envelope, lighting and HVAC systems [110]. The green building requirements apply to: - Private office and commercial/industrial buildings throughout Ghana that are above 5000 m^2 total gross floor area - Public buildings located in all the regional and district capitals that are above 500 m^2 in total gross floor area - Residential buildings throughout Ghana that are above 75 m^2

Energy Efficiency Standards and Labelling (non-ducted air conditioners and self-ballasted fluorescent lamps) LI 1815	
Document type	Regulation
Date	2005
Status	In force
Building's type	All
Building's part	Appliances
Building's category	All
Steering body	Ghana Standards Authority
Technical requirements	Minimum performance requirements: 1) A non-ducted air conditioner manufactured or imported for use in Ghana shall in accordance with Ghana Standard 362:2001 have a minimum energy efficiency ratio of 2.8. 2) A self-ballasted fluorescent lamp manufactured or imported for use in Ghana shall in accordance with Ghana Standard GS 324:2003 have: ○ a minimum rated life of six thousand hours; and ○ a minimum efficacy measured in lumens per watt matching the lamp configuration (bare or covered with or without reflector) and lamp power (LP) rating as provided for in Schedule I [111].

Energy efficiency (prohibition of manufacture, sale, or importation of incandescent filament lamp, used refrigerator, used refrigerator, freezer, used freezer and used air conditioner) regulations - LI 1932	
Document type	Regulation
Date	2008
Status	In force
Building's type	All
Building's part	Appliances
Building's category	All
Steering body	Ghana Standards Authority
Technical requirements	This regulation prohibits to manufacture, sell, or import incandescent filament lamps. Moreover, it prohibits to import and/or sell imported used air conditioners, used refrigerators, and used freezers [112].

The GhBC indicates that a new edition will be promulgated every 4 years to include proposed changes submitted by code enforcement officials, industry representatives, design professionals, government officials and other stakeholders. This is positive indication about the willingness of Ghana Standards Authority to lead a pattern of continuous improvement of the Code, hence potentially allowing future climate and technologies consideration to be taken into account. In addition, the GhBC explicitly mentions and uses three passive techniques strategies: Passive ventilation, passive cooling, and day lighting.

2.2.7 Senegal

According to Senegal's Energy Control Strategy, the total final energy consumption of Senegal's energy sector was approximately 2360 ktoe in 2013, and in the absence of an active energy conservation strategy, it will continue to grow steadily to reach 5,165 ktoe in 2030, an increase of 119% at an annual rate of 4.7%.

In Senegal, energy control has emerged as a major political issue. The implementation of the new energy sector development policy (LPDSE, 2012) [113], which aims, among other things, at a renewable energy penetration rate (excluding traditional biomass) of at least 15% by 2025, a reduction of 10 to 20% in the public electricity bill, and an energy savings of around 40% on electricity demand in 2020, by 2020.

It is in this context that the National Energy Economy Agency (ANEE) was created by decree No. 2011 - 1054 of July 28, 2011, which will be transformed into the Agency for Economy and Energy Control (AEME).

The Agency for economics and energy control (AEME) is a public institution with financial and administrative autonomy. Technically, it depends on the Ministry of Oil and Energy, while the Ministry of Economy and Finance provides financial supervision. In this perspective, several regulatory measures have been put in place, including:

Decree No. 2011-160 banning the import and production of incandescent lamps in Senegal and promoting energy-saving lamps **[114]**	
Document type	Decree

Date	2011
Status	In force
Building's type	All
Building's part	Appliances
Building's category	All
Steering body	The Minister of State, Minister of Economy and Finance, Minister of State, Minister of State Environment and Nature Protection, Minister of State, Minister of International Cooperation, Air Transport, Infrastructure and Energy, Minister of State, Minister of Mines, Industry, Agribusiness and SMEs and Minister of Trade
Technical requirements	▪ Senegal prohibits the importation and production of incandescent lamps, apart from halogen-type lamps, as of March 1, 2011. ▪ Import and production of energy-saving lamps, such as fluorescent lamps and LEDs are permitted. ▪ Energy-saving lamps imported or manufactured in the country must meet international standards mandated by a joint order of the Ministers of Energy and Standards.

Energy efficiency policy of ECOWAS [115]	
Document type	Policy
Date	2013
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	ECOWAS
Requirements	▪ Eliminate incandescent lamps by 2020, ▪ Adopt regional standards and labels for key energy equipment by 2014, ▪ Develop and adopt regional energy efficiency standards and codes for buildings, ▪ Encourage passive bioclimatic architecture to reduce the need for "Active" air conditioning. ▪ Regulating markets through labels, minimum standards of energy performance, testing and certifications, ▪ Create an energy efficiency label for ECOWAS, ▪ Develop building guides for building owners and construction companies.

Directive Number 04/2020/cm/UEMOA on energy labelling of electric lamps and household appliances	
Document type	Directive
Date	2020
Status	In force
Building's type	All

Building's part	New Appliances
Building's category	All
Steering body	West African economic and monetary union
Requirements	This directive applies to the following new equipment: ▪ Domestic refrigeration equipment (refrigerators, freezers and combined appliances), ▪ Air conditioners, ▪ Electric lights. The directive specifies the content of the energy label, the methods of labelling and energy classification of each item of equipment, and the obligations of suppliers and sellers [116].

Directive number 05/2020 setting energy efficiency measures in building construction in WAEMU member states [117]	
Document type	Directive
Date	2020
Status	In force
Building's type	All
Building's part	All
Building's category	Existing building subject to major renovation
Steering body	West African Economic and Monetary Union
Requirements	The directive specifies the type and part of the building concerned. The technical requirements to be met are defined according to 3 approaches: ▪ Prescriptive approach: sets minimum technical specifications on the thermo-physical properties of building envelope components and electromechanical systems. ▪ Compromise approach: sets minimum technical specifications for more general building parameters. These are calculated from the properties of the building. ▪ "Energy budget" type performance method approach sets the annual energy consumption not to be exceeded while considering prescriptive requirements and climatic zoning. The building's energy performance is determined using approved software. Considering renewable energies up to 10% of the need for domestic hot water and 5% of the need for electricity is mandatory according to this directive.

The Senegalese Institute of Standardization, established by decree 78 228 on 14 March 1978, is part of the Ministry of Industry and Crafts. It has been known as the Senegalese Association for Normalization (ASN) since 19 July 2002.

The ASN's mission is to:

- Carry out actions to develop national standards, information, awareness, and training.

- Promote quality in order to support the efforts of economic agents in this area the main standards developed in the field of energy efficiency in buildings are:

NS 02-061- Building components and building elements—Thermal resistance and thermal transmittance—Calculation method [118, p. 061]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	The standard specifies how to calculate the thermal resistance and thermal transmittance of building components and elements that do not include doors, windows, and other glazed units, curtain walling, components that involve heat transfer to the ground, and components through which air is designed to permeate.

NS 02 – 063-1- Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 1: General [119, pp. 063–1]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	The standard specifies methods for calculating the thermal transmittance of windows and pedestrian doors made up of glazed and/or opaque panels fitted in a frame, both with and without shutters. The standard allows for the following: ▪ varying glazing types (glass or plastic; single or multiple glazing; with or without low emissivity coatings; and spaces filled with air or other gases). ▪ Opacity of the panels within the window or door. ▪ Various types of frames (wood, plastic, metallic with and without thermal barrier, metallic with pinpoint metallic connections, or any combination of materials). ▪ Where applicable, the additional thermal resistance introduced by different types of closed shutters based on their air permeability.

NS 02 – 064- Thermal bridges in building construction—Heat flows and surface temperatures—Detailed calculations [120, p. 064]

Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	The standard specifies the requirements for a three-dimensional and a two-dimensional geometrical model of a thermal bridge for numerically calculating: ▪ heat flows, ▪ minimum surface temperatures, The geometrical boundaries and subdivisions of the model, the thermal boundary conditions, and the thermal values and relationships to be used are all specified.

NS 02 – 065-2- Thermal performance of windows and doors—Determination of thermal transmittance by hot box method—Part 2: Roof windows and other projecting windows [121]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	ISO 12567-2:2005 defines a method for measuring the thermal transmittance of roof and projecting windows. It excludes edge effects that occur outside the specimen's perimeter, energy transfer caused by solar radiation on the specimen, and the effects of air leakage through the specimen.

NS 02 –066- Thermal performance of buildings - Heat transfer via the ground - Calculation methods [122, pp. 02–66]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization

Requirements	The standard specifies heat transfer coefficients and heat flow rates for building elements in thermal contact with the ground, such as slab-on-ground floors, suspended floors, and basements. It applies to building elements or parts of building elements located below a horizontal plane in the building's bounding walls.

NS 02 – 067-1 Buildings and constructed assets - Service life planning - Part 1: General principles [123, p. 1]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	Life prediction is a design process that ensures, to the greatest extent possible, that the lifespan of a building equals or exceeds the lifespan at design while considering (and preferably optimizing) the building's life cycle costs. This section of the standard provides a methodology for forecasting service life and estimating the necessary component maintenance and replacement schedule. As a result, it allows for the comparison of various building options. It also allows you to ensure that performance is not being reduced in an unacceptable way in order to meet budget constraints during design.

NS 02 – 067-2 Buildings and constructed assets -Service life planning - Part 2: Service life prediction procedures [124, pp. 02-067–2]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	This section of ISO 15686 describes procedures for predicting the service life of building components. It includes a model plan, principles, and general prescriptions for conducting these studies and writing their reports.

NS 02 – 067-3 Buildings and constructed assets - Service life planning - Part 3: Performance audits and reviews [125, pp. 02-067–3]	
Document type	Standard

Date	2014
Status	Approved standard
Building's type	All
Building's part	All
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	The standard is concerned with ensuring that service life planning is implemented effectively. It describes the approach and procedures to be used in pre-briefing, briefing, design, construction, and, if necessary, life care management and disposal of buildings and constructed assets to provide reasonable assurance that the measures required to achieve satisfactory performance over time will be taken.

NS 02 – 067-08- Buildings and constructed assets - Service-life planning - Part 8: Reference service life and service-life estimation [126, pp. 02-067–08]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	The standard specifies how to provide, select, and format reference service-life data, as well as how to use these data to calculate estimated service life using the factor method.

NS 02 – 068- Building environment design - Indoor air quality - Methods of expressing the quality of indoor air for human occupancy [127, pp. 02–068]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All buildings except residential, industrial and hospital buildings
Building's part	Ventilation appliances
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	The purpose of this International Standard is to: ▪ specify methods for expressing the quality of indoor air suitable for a human occupancy, ▪ allow several acceptable target levels of IAQ, depending on local requirements, constraints and expectations. This International Standard applies to the design of new buildings and their systems, as well as the rehabilitation of existing buildings and

	systems, indoor environments where human occupants are the primary concern, buildings incorporating any combination of mechanical and natural ventilation, commercial and institutional structures.

NS 02 – 069- Building materials and products - Hygrothermal properties - Tabulated design values and procedures for determining declared and design thermal values [127, pp. 02–069]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	The standard specifies methods for determining declared and design thermal values for thermally homogeneous building materials and products, as well as procedures for converting values obtained under one set of conditions to those valid under another. These procedures are applicable for design ambient temperatures ranging from -30 °C to +60 °C. The standard includes temperature and moisture conversion coefficients. These coefficients are valid for mean temperatures ranging from 0 °C to 30 °C. The standard also includes tabular design data for thermally homogeneous materials and products commonly used in building construction for use in heat and moisture transfer calculations.

NS 02 – 070- Thermal insulation - Heat transfer conditions and properties of materials – Vocabulary [128, pp. 02–070]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	This International Standard defines terms used to describe heat transfer conditions and material properties in the field of thermal insulation.

NS 02–71- Thermal insulation - Heat transfer by radiation - Physical quantities and definitions [129, pp. 02–71]	
Document type	Standard

Date	2014
Status	Approved standard
Building's type	All
Building's part	Envelop
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	This International Standard defines physical quantities and other terms related to heat transfer by radiation in the field of thermal insulation.

NS 02 – 72- Building environment design - Guidelines to assess energy efficiency of new buildings [130, pp. 02–072]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	New buildings
Building's part	All
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	This International Standard, as presented in ISO 16813, provides guidelines for considering the energy efficiency of buildings. The goals of this International Standard are to assist designers and stakeholders in gathering and providing useful data for each step of the design and development process in accordance with building definitions prepared by designers.

NS 02 – 74- Building environment design - Indoor environment - General Principles [131, pp. 02–74]	
Document type	Standard
Date	2014
Status	Approved standard
Building's type	All
Building's part	All
Building's category	All
Steering body	Senegalese Association for Normalization
Requirements	The standard establishes the general principles of building environment design while considering healthy indoor environments for occupants and environmental protection for future generations. The distinguishing characteristics: ▪ to provide constraints regarding sustainability issues from the beginning of the design process, including building and plant life cycle costs, as well as owning and operating costs, to be considered at all stages of the design process.

	▪ To evaluate the proposed design at each stage of the design process using rational criteria for indoor air quality, thermal comfort, acoustical comfort, visual comfort, energy efficiency, and HVAC system controls to iterate between design decisions and evaluations throughout the design process.

Senegal is a country where interest in energy efficiency in buildings is beginning to occupy an important place, which is reflected by the adoption of many international standards in the field. However, the regulatory framework is very underdeveloped and requires special attention, also given the rapid changes in the field, certain frameworks and directives need to be made more flexible by not setting certain thresholds in law as to allow for less administrative lead-in time to make changes and adjustments.

In fact, an energy efficiency policy has been put in place to form the basis of the regulatory infrastructure in terms of energy efficiency in buildings. Depending on climatic zones and approaches, it specifies the requirements that the envelope of a new building must meet or the energy consumption not to be exceeded, this includes the shape, orientation, use of renewable energies, etc. Indeed, the passive part of the building is taken into consideration, but the focus is mainly on the energy performance of the equipment used. However, this regulation remains basic and does not include future climate data or developed technologies.

As a result, the main recommendations that emerged, according to the energy efficiency national Action Plan [2015-2020/2030] [132] are:

- **Strengthen the institutional framework:**
  - Establish a local information-advisory centre dedicated to energy efficiency.
  - Establishment of provisions for monitoring the application of regulations: establishment of a control and monitoring centre for the monitoring of application of regulations.
- **Strengthen the regulatory framework:**
  - Create a law to promote energy efficiency by the implementation of actions to promote energy efficiency in buildings.
  - Implement a mandatory labelling system for goods and services in order to improve consumer information and encourage them to purchase energy-efficient equipment.
  - Implement MEPS for electrical equipment and remove energy-intensive equipment from the market.
  - Create economic and financial incentives to encourage users to use energy wisely.

2.2.8 Nigeria

The building sector accounts for most Nigeria's electricity consumption, which will inevitably increase significantly in absolute terms in the coming years due to a rapidly growing population,

migration from low-energy-consuming rural dwellings to urban centres, and improvements in living standards. This is the reason why energy control through the development of energy efficiency measures in this area is crucial.

The establishment of the Energy Commission of Nigeria (ECN) as the governmental organ responsible for the coordination of energy sector activities and the implementation of a comprehensive and integrated energy policy is a significant development in this regard.

The Energy Commission of Nigeria conceived the first National Energy Policy for Nigeria, which was approved by the Federal Executive Council in 2003 and launched on June 20, 2005. It was re-evaluated in 2013, and again in 2018.

National energy policy [133] [134]	
Document type	Policy
Date	2003–2013 - 2018
Status	In force
Building's type	All
Building's part	All
Building's category	All
Steering body	Energy commission of Nigeria
Requirements	This policy encourages the following elements: ▪ Creating building codes that allow buildings to take advantage of climatic conditions in order to reduce energy consumption. ▪ Ensuring the importation of the more energy-efficient equipment and machinery. ▪ Increasing public awareness of the advantages of increased energy efficiency. It also defines long, medium- and short-term energy conservation strategies as follows: **Prioritization of Strategies into Short and medium term:** **Short term measures in energy efficiency and conservation:** ▪ Development of energy-saving codes, standards, regulations, and guidelines, as well as the use of energy-efficient methods, equipment, machinery, and technologies in building design and construction **Medium Term Measures in energy efficiency and conservation:** ▪ Implementation of energy conservation codes, standards, regulations, and guidelines, as well as the use of energy-efficient methods, equipment, machinery, and technologies in building design and construction.

Physical planning and development regulations [135]	
Document type	Regulation
Date	2005
Status	In force
Building's type	All
Building's part	Envelop

Building's category	New and existing buildings
Steering body	Physical planning and development authority
Technical requirements	Every room in a building shall be provided with the following: ▪ Natural lighting by means of windows, doors or other recognized transmitting media, ▪ Natural ventilation by means of windows, doors or any recognized ventilation openings.

National building code [136]	
Document type	Code
Date	2006
Status	In force
Building's type	Tertiary and residential buildings
Building's part	Envelop
Building's category	New and existing buildings
Steering body	Ministry of power, works and housing
Technical requirements	This code specifies for different types of buildings and premises: ▪ The criteria of natural and mechanical ventilation required, ▪ The technical characteristics of artificial and natural lighting ▪ The insulation needs.

National renewable energy and energy efficiency policy (NREEEP) [137]	
Document type	Policy
Date	2014
Status	In force
Building's type	Residential and tertiary
Building's part	Envelope and appliances
Building's category	All
Steering body	Energy commission of Nigeria
Requirements	This policy defines long, medium- and short-term energy conservation strategies as follows: ▪ Increasing the effectiveness of existing institutional and legal frameworks for promoting energy efficiency and conservation. ▪ Adopting appropriate policy instruments, such as building standards, codes, mandatory labelling, soft loans, tax credits, investment subsidies, and mandatory energy audits. ▪ Promoting the formation of Energy Services Companies (ESCOs). ▪ Creating and enforcing Minimum Energy Performance Standards (MEPS) for equipment and appliances.

- By 2025, all incandescent light bulbs in Nigerian homes, institutions, and establishments have to be replaced with LEDs and other high energy saving lamps.
- By 2025, a wide range of equipment energy efficiency standards and labelling must be in place.

Specific strategies are also defined in short, medium and long term for each sector as follows:

Short-Term

- Promoting the use of energy-efficient domestic cookstoves in the residential sector.
- Designing, promoting and implementing Minimum Energy Performance Standards (MEPS) and mandatory labelling for household energy – consuming appliances.
- Encouraging widespread adoption of energy saving lamps e.g., Light Emitting Diodes (LEDs) and compact fluorescent lamps (CFLs) and the phasing-out of inefficient lamps e.g., incandescent bulbs.
- Keenly following trend in technology changes in household energy appliances to take advantage of emerging energy efficient and renewable energy technologies (e.g., solar water heaters, solar PV, etc.).
- Introducing Energy Audit Programs in Buildings.
- Building Energy Consumption Databases - Energy End-Use Database.
- Establishing Guidelines for Energy Efficient Practices in all Government Buildings.

Medium-Term

- Incorporating energy efficient standards into the National Building Code.
- Establishing a framework for adoption and promotion of installation of smart meters or Pay as You Consume (PAYC) meters in all households by 2025,
- Integrating designs optimize the use of passive design and climatic conditions e.g., day lighting and natural ventilation.
- Developing and implementing building energy-efficiency and conservation standards and codes.
- Introducing Green Building Standard and Certification System.

Long-Term

- Achieving by 2030 universal access to safe, clean, affordable, efficient and sustainable cook stoves/fuel switching to LPG in all households.
- Equipping 50% of educational institutions and all health centres, and 15% of all hotels and agro-food industries with solar thermal heating systems to meet their hot water needs by 2025.

The Building Energy Efficiency Code establishes minimum efficiency requirements for new buildings in order to achieve reductions in energy use and greenhouse gas emissions over the life of the building. It saves building owners and renters a lot of money on their energy bills.

National building energy efficiency code [138]	
Document type	Code
Date	2017
Status	Voluntary for up to 2 years then mandatory
Building's type	All
Building's part	All
Building's category	New buildings
Steering body	The Federal Ministry responsible for the National Building Energy Efficiency Code.
	Two methods are possible to demonstrate compliance. ▪ Compliance Method 1 Prescriptive approach: For this option, building projects must adhere to all the requirements as a checklist. ▪ Compliance Method 2 Performance approach: Project teams may deviate from the prescriptive requirements, provided that the theoretical energy use of the building is less than or equal to that of the same building with all the prescriptive requirements included. A whole building analysis using energy simulation software must be carried out.

Nigeria has a multitude of laws related to energy efficiency identifying guidelines to be put in place to promote energy efficiency in buildings, without, however, putting in place orders and decrees to apply these laws. These laws contain articles specifying the energy performance law projects to be developed for the active and passive part of the building without including the characteristics of bioclimatic buildings or considering future climatic data.

The implementation of energy efficiency in the building sector in Nigeria still encounters several obstacles defined by a report consisting of an "Energy Efficiency Survey in Nigeria, A Guide for Developing Policy and Legislation" [139] as:

- **Lack of Policy and Legislation**: A major impediment to the development of energy efficiency is a lack of policy and legislation to address inefficient energy use. Policy and legislation will aid in shifting behaviour toward a more energy-efficient economy. Private and public institutions should be encouraged to develop their own policies to promote energy efficiency. The government can make it mandatory for public- and private-sector organizations, both large and small, to establish an energy management department or unit.
- **Lack of trained personnel and energy efficiency professionals**: Inadequately trained personnel and professionals are another impediment to the advancement of energy efficiency.
- **Importation of used machines**: The proliferation of imported second-hand appliances may make it difficult to use energy-efficient appliances. Because second-hand equipment is inexpensive and widely available, new, and efficient equipment may be unable to compete in the market.

- **Low income**: Approximately 70% of Nigerians live below the poverty line of $2 per day. Many people cannot afford the cost of high-efficiency appliances, which are sometimes more expensive than lower-efficiency models.

The same source defines important recommendations to develop the energy efficiency sector, the most important is one related to elaboration of:

- Policy includes phasing out incandescent bulbs from the Nigerian system and prohibiting the importation and manufacture of incandescent bulbs.
- Policy that encourages the importation and production of energy-efficient light bulbs will improve energy efficiency. The government should implement strategies to lower the cost of energy-saving bulbs.
- Policy should be enacted to make it mandatory for residents, public and private building occupants to turn off their security lights during the day.
- Policy should be developed to hold public officials and users of public buildings accountable for the energy they consume. Public and private institutions should create their own energy management policies that limit the use of specific appliances. It should also be made mandatory for public and private buildings to conduct energy audits and make the results public.
- Policy should be developed to promote the use of central air conditioning systems rather than individual air conditioners.
- The government should enact policies that encourage hotel operators to use solar heaters instead of electricity. This could be in the form of a tax break or compensation for being environmentally friendly. The less efficient ones can be penalized and forced to pay a fine, which will be used to encourage the more efficient ones.
- A policy to standardize used goods imported into the country is required. There is also a need to develop policies that encourage Nigerians to buy new and modern appliances.
- To establish a ministry or agency in charge of promoting energy efficiency. The agency will oversee the implementation of energy efficiency policies and programs. They will also ensure that information on energy efficiency is widely disseminated, as well as that training and retraining of energy efficiency staff in various establishments is done on a regular basis.
- To establish a National Energy Efficiency Fund. This fund's funding may come from taxes paid by companies involved in petroleum exploration. Another possible source is the penalty paid by companies that emit greenhouse gases, as well as energy taxes.

3. Analysis

The regulatory infrastructure related to energy efficiency in buildings in the European Union countries is highly developed. Indeed, it includes laws, regulations, labels, codes, certificates, MEPS, standards, and energy labels for both the passive and active parts of the building.

This infrastructure is aimed not only at reducing energy but also at setting up passive buildings until reaching zero-energy buildings. It is supported by the creation of an institutional framework, financial incentives and demonstration pilot programs dedicated to energy efficiency in buildings.

However, the diversification of the regulatory framework and incentive programs has created ambiguity among consumers. Therefore, the main recommendation for these countries lies in strengthening the homogenization of the various legal texts and the development of awareness and information for citizens to better guide them.

While for the countries of North Africa, the regulatory framework for energy efficiency in buildings is moderately developed. It includes laws and regulations related to the building envelope, MEPS, and energy labels for some electrical equipment (mainly lamps, air conditioners, refrigerators) and standards. At the same time, the energy labels and classification for the entire building are still in development. Although this area is also experiencing an overhaul of the institutional frameworks and financial incentive programmes, these actions remain minimal. We also note that the obligation of technical requirements to have passive and bioclimatic buildings is far from being possible in these countries.

Indeed, the application of the currently existing basic recommendations knows several obstacles, mainly: the lack of a complete regulatory framework, control, and monitoring bodies for the implementation of the obligations and a lack of technical expertise of managers in the existing organizations. The financial incentive framework and demonstration programs as well as citizen awareness must also be upgraded.

On the other hand, the regulatory framework for energy efficiency in buildings is very poorly developed or non-existent in West African countries. Despite the growing interest of these countries in developing energy efficiency in general and in the building sector, there are only a few laws, standards and energy labels for electrical equipment. There are also a few demonstration programs in the field.

Effectively, energy efficiency in this area faces many obstacles related to a considerable lack at the legislative, regulatory, institutional, and financial level. Therefore, it is recommended to develop the domain based on advanced countries' experience to avoid the beginner's mistakes.

The following table summarizes the regulatory landscape observed in selected countries of Europe and Africa.

3.1. Overview of regulation in the EU, North and West Africa regions

The following two tables give an overview on the regulations described in the previous chapters.

Table 1: Overview of regulations on EE in buildings in the EU, North and West Africa regions

Technical requirement	Germany	France	Tunisia	Senegal	Nigeria	Italy	Morocco	Ghana	Egypt	Spain	Portugal	Algeria	Libya
Framework law on energy efficiency in buildings	X	X	X	X	X	X	X		X	X	X	X	X
Limitation of the yearly final energy demand by a maximum value for heating and cooling	X	X	X	X			X			X	X	X	
Specified heat transfer coefficient for building component	X	X	X	X		X	X		X	X	X	X	
Energy efficiency label for buildings	X	X	X		X	X	In progress			X	X		
Phasing out of incandescent lamps used in buildings	X	X		X				X		X	X		X
Appliances labelling	X	X	To be extended	To be extended		X	X		X	X	X		
MEPS for appliances	X	X	To be extended	To be extended		X	X	X	X	X	X		
Mandatory audits	X	X	X				X			X	X		
Energy audits and consulting on plan	X	X	X							X	X		
Requirements on the energy performance of buildings so they will have to be “Nearly Zero Energy Buildings.”	X	X											

4. Regulatory Infrastructure Conclusion

This study showed the great disparity in the development of regulatory infrastructure for energy efficiency in buildings in the EU, North and West African regions. For the countries of European Union, the regulatory framework for energy efficiency in buildings is highly developed. While in North Africa is moderately developed and it is very poorly developed in West Africa.

In the countries of the European Union, the development of codes and regulations related to the control of energy consumption in buildings has begun since the 1970s. Since then, several codes integrating bioclimatic aspects have been putted in place for building envelope, while for the used energy installations, regulations and MEPS specifying the technical characteristics to be respected are developed. Initially, the emphasis was placed on heating equipment given the growing need in the region without hindering the promotion of the energy efficiency of the envelope which holds the priority. Over time, the updating of regulations takes into account the new technologies developed in the field and the observed climate changes without integrating future climate predictions.

In the countries of North Africa, the importance attributed to energy efficiency in buildings is reflected in the development of building codes that specify requirements on the building envelope, this includes new and under renovation buildings (for some countries). These codes are applied through regulations and decrees identifying the consumption limits not to be exceeded, the verification and control institutions and the penalties for non-compliance. Compliance with these technical requirements leads to the integration of bioclimatic building measures into the building under construction (orientation, natural ventilation, etc.). These regulations are developed based on dynamic thermal simulations using old climatic data. Unfortunately, the updating of these requirements considering future climate changes is still not done.

Most West African countries have a building code that mainly includes construction methods and rules, while few include energy efficiency measures. All the same, these countries are starting to develop common energy efficiency policies to the ECOWAS countries. These policies provide guidelines and large-scale projects to follow the development of energy efficiency in buildings. The application of these directives is carried out through national pilot projects which remain minimal and insufficient. The few existing regulations in the region implicitly include bioclimatic aspects but give more importance to the integration of energy production systems from renewable sources (photovoltaic and thermal solar system).

In this context, South-South and triangular cooperation is an essential institutional tool for overcoming this disparity and strengthening the capacities of West African and North African countries.

Below is a list of general recommendations for North and West African countries:

- Provide institutional and technical support to local and foreign manufacturers of energy efficient materials and appliances (e.g., tax reduction for big manufacturers; incentives, encourage young entrepreneurs and start-ups).
- Expand market development and financing partnership with banks and private companies.
- Promote building codes among architects, designers, and public authorities, through awareness campaigns and capacity building.

- Create a training infrastructure for engineers and architects and develop competent technicians using retrofit tools and equipment know-how.
- Involve universities and the research academic community to propose appropriate technologies and possible solutions.
- Create a database of energy efficiency pilot and demonstration projects in Africa. These projects could serve as a reference for future construction and renovation projects.

The policy context of NW-Africa and Europe, their application, effectiveness and barriers will be further discussed in another work inside ABC 21 framework entitled D2.4 – Policy Overview.

Chapter 2: Training Infrastructure in North-West Africa & Europe

5. Training on Energy Efficiency in Buildings

Energy is a key sector of the economy, both because of its importance as an industry and, above all, because of its strategic value, since energy is an essential element of any industry or service. The objectives of a sustainable energy policy must be security of energy supply, competitiveness of energy markets and protection of the environment.

Energy-efficient buildings are a cornerstone of a prosperous, sustainable and healthy society. Training on EE in buildings aims to prepare key stakeholders to successfully facilitate energy efficient building construction and retrofits. It does so by introducing the fundamentals of how building design can reduce energy use, the benefits of reducing energy waste, the policy landscape, codes and standards, data and indicators, and financing [140].

5.1. European Union Level

Buildings consume 40% of the EU's energy and 55% of its electricity and produce 36% of its CO2 emissions. As a result, enhancing the energy performance of buildings and increasing the use of renewable energy are critical steps toward meeting the EU's 2030 targets. However, the rate of existing building renovation is currently low – between 1% and 2% of the building stock is renovated each year.

In order to support energy efficiency projects in the building sector, training programs have been developed and are intended for decision-makers, engineers, technicians and project managers working in the public and private sectors or on behalf of federations and professional and associative groups concerned by the act of building.

The overall objective of the EE / building training is to build national and African expertise in favor of the development of the energy efficiency market, to set up, carry out and monitor building construction projects in accordance with the regulations in force.

Among the existing initiative, there is BUILD UP Skills. It is an EU-promoted initiative on continuous "education and training of craftsmen and other on-site construction workers and systems installers in the building sector" to enable the Clean Energy Transition. The initiative was launched in 2011. It seeks to "increase the number of qualified workers across Europe, to deliver building renovations which offer high-energy performance as well as new, nearly zero-energy buildings (NZEBs)". It covers "skills in relation to energy efficiency and renewable energy systems and measures" in the building stock [141].

5.1.1. Germany

By 2050, the federal government of Germany intends to achieve an almost climate-neutral building stock. To achieve this goal, Germany wants to increase the share of renewable energies in its heat consumption and to have more energy efficient buildings [142].

The energy efficiency strategy for buildings integrates the fields of electricity, heat and efficiency, thus creating a clearly defined framework for action for the energy transition in the buildings sector.

In that sense, Germany's private sector and public institutions offer a wide range of courses, both academic and professional, which revolve around capacity building of energy efficiency in buildings sector. Hereafters are examples of training programs and modules on EE in buildings and urban development who are the subject of this study.

5.1.1.1. Energy Efficiency in Building Training

1.DEN Akademie [143]	
Institution status	Private
Course title	Energy and energy efficiency, climate protection, subsidies for the energy consultancy industry.
Type of Training/Course	Professional: seminars, courses, in-house training courses and lectures
Duration	1–2days/online
Beneficiaries	Professionals
Obtained Diploma/Certificate	Certificate
Description	Several programs are offered by the academy, including: Contract and project practice for energetic renovation and KfW construction supervision: This seminar offers a basic introduction to the individual renovation schedule (iSFP). The iSFP shows the successive renovation steps graphically and conveys the renovation steps in an easy-to-understand way. The iSFP can be used for a complete renovation in one go (to the efficiency house) or for a step-by-step renovation with various packages of measures. Course for non-residential buildings, facilities, and systems Module 1: Energy audit

2. RENAC Renewables Academy AG [144]	
Institution status	Private
Course title	Applying Energy Efficiency
Type of Training/Course	Professional
Duration	6 months
Beneficiaries	This training will suit those who: • Develop strategies for implementing energy efficiency projects. • Want to assess the saving potential of cross-sectional technologies. • Are planning to set up energy management systems and/or energy audits.
Obtained Diploma/Certificate	RENAC certificate upon successful finalisation of the training

Description	Applying Energy Efficiency provides a comprehensive overview of technical and economic aspects of energy efficiency measures. The online training presents support mechanisms for energy efficiency projects and points out saving potentials in the industrial sector as well as in the built environment. Organizational aspects, such as energy management systems and energy audits, are also covered. Courses: • Introduction to energy efficiency projects • Support mechanisms for energy efficiency projects • Systematic approaches to energy saving • Energy efficiency in the industry • Energy-efficient buildings Live virtual classrooms (webinars): • Technological aspects of energy efficiency • Cross-sectional energy efficiency technologies

3. TU Berlin [145]	
Institution status	Pubic
Course title	Building Sustainability – Management Methods for Energy Efficiency
Type of Training/Course	Academic
Duration	3 semesters
Beneficiaries	A first university degree qualifying a graduate for professional work and subsequent relevant professional experience of not less than one year.
Obtained Diploma/Certificate	M.B.A
Description	The energy-efficient management of buildings and neighbourhoods is one of the key factors for a successful energy revolution. The continuing education master's program in Building Sustainability - Management Methods for Energy Efficiency equips you with specialist knowledge in this area, focusing on the implementation of sustainability in a variety of urban contexts. Students acquire professionally relevant and broad-based technical and business economics knowledge as well as an understanding of management in a program tailored to the requirements of the real estate sector. Examples of areas you address include building automation, energy efficiency and energy generation, real estate management, and intelligent buildings. Beneficiaries will additionally acquire skills in project and life-cycle management as well as an understanding of global perspectives concerning the different approaches to energy efficiency. [7]

4. Beuth University of Applied Sciences in Berlin [147]	
Institution status	Public
Course title	Green Building Design
Type of Training/Course	Academic
Duration	4 semesters
Beneficiaries	Access to the master's degree in the planning of sustainable buildings is granted to those who have acquired a first professional university degree (bachelor's or diploma) in one of the following degree programs: • Building and energy technology • Civil engineering • facility management • Landscape architecture
Obtained Diploma/Certificate	Master's degree
Description	In the interdisciplinary master's program Planning of Sustainable Buildings, bachelor graduates in building-related subjects learn and experience the joint development, planning and operation of sustainable buildings in a practice-oriented manner. The course content is based on the one hand, on the tried and tested teaching content of civil engineering, as taught in the architecture, building technology, civil engineering or comparable construction or building-related subjects. On the other hand, this teaching content is expanded in a targeted manner, for example with ecological topics and questions or the instructions for using Building Information Modelling (BIM) as a planning tool. Among the courses and modules taught in the degree, we find: **Basic modules:** • Building physics and energy efficiency • Integrated building technology 1/2 • Environment 1 - use and location • Design implementation in the new building • Environment 2 - inventory analysis • Design implementation in the existing building **Elective modules:** • Material efficiency and recycling • Thermal Optimization

5. Beuth University of Applied Sciences in Berlin [148]	
Institution status	Public
Course title	Building Services and Energy Technology
Type of Training/Course	Academic

Duration	6 semesters
Beneficiaries	Students with a technical college entrance qualification, general or subject-specific university entrance qualification or another law-enforcement eligibility to study
Obtained Diploma/Certificate	Bachelor of Engineering (B.Eng.)
Description	The engineering course in building and energy technology includes the building technology disciplines of heating technology, air conditioning technology, sanitary technology and electrical, measurement and control technology as well as energy and environmental technology. The course consists of coordinated modules. In order to complete the standard period of study, six modules have to be completed per semester. Among the courses taught in this bachelor's degree are: • Refrigeration and heat pumps • CAE building and energy technology II, application • Heating technology II, design of energy-efficient systems • Ventilation technology II, design of energy-efficient systems • Sanitary technology II, planning of gas and water systems • Energy and environmental technology • Engineering basics of energy technology I/II/III • CAE building and energy technology I/II/III • Building construction and thermal and fire protection • Electrical, measurement and control technology I • Heating technology I, basics and needs assessment • Ventilation technology I, comfort and needs assessment

5.1.1.2. Urban Planning Trainings

6. Darmstadt University of Technology [149]	
Institution status	Public
Course title	Sustainable Urban Development
Type of Training/Course	Academic
Duration	2 years/4 Semesters
Beneficiaries	Students holding a Bachelor of Science degree or Bachelor of Engineering degree in a similar or an equivalent degree (additional requirements might apply on the potential beneficiaries)
Obtained Diploma/Certificate	Master's degree
Description	The Joint Degree Master Programme "Sustainable Urban Development" is a full-time Master Programme at the Vietnamese-German University (VGU) in Ho Chi Minh City and

	the Technical University of Darmstadt. Like the topic "Sustainable Urban Development" itself, the programme is multi- and interdisciplinary. Students are introduced to the methods required to solve the challenges of sustainable urban development on a project-related basis. Graduates of this programme are able to initiate, control and implement processes of sustainable urban development at various levels (regional, citywide, neighbourhood-related, construction project-related). The courses taught in the SUD M.Sc. are: • Water in Urban Development • Ecological Management in Urban Development • Methodology of Empirical Analysis • German Law of Property and Planning • Sustainable Waste Management and Life Cycle • Assessment Application • Urban Rural Partnerships • GIS and Applications to Urban Development • Infrastructure Planning • Instruments of Spatial Planning • Urban Development and Architecture of Cities • Green Building Design II • Urban Transport Planning • English Scientific Writing • Urban Construction Technologies • Development Planning and Governance

7. Ruhr University Bochum [150]	
Institution status	Public
Course title	Transformation of Urban Landscapes TUL
Type of Training/Course	Academic
Duration	2 years/4 semesters
Beneficiaries	Students with a B.A/Sc. degree in Geography, Spatial Planning ("Raumplanung") or similar equivalent study programmes from Germany or other countries and thorough knowledge of English.
Obtained Diploma/Certificate	Masters' degree
Description	The Double Degree Master Programme "Transformation of urban Landscapes (TuL)" focuses on the present and future challenges in developing sustainable metropolitan regions and facilitates the necessary professional competence to cope with those challenges in both growing and shrinking regions.

5.1.2. Spain

Given the measures that were taken by Spain in response to the EU Directive 2010/31/EU on the energy performance of buildings, the necessity to build capacity around EE in building arose. Below are examples of offered training programs in the country.

5.1.2.1. Energy Efficiency in Buildings Training

8. University of Navarra [151]	
Institution status	Public
Course title	Environmental Design and Management of Buildings
Type of Training/Course	Academic
Duration	1 year
Beneficiaries	Recent graduate or graduate in Architecture, Engineering or other equivalent qualification; who is interested in specializing his/her professional career toward areas related to the management, design, construction and maintenance of buildings with environmental measures that not only reduce energy consumption but also reduce other impacts (waste, spillage, noise) that construction and use of buildings [152]. Professionals in the sector, with a university degree and little professional experience (1 or 2 years), who want to make a qualitative leap in their career also fit the profile.
Obtained Diploma/Certificate	Master's degree
Description	The Master in Environmental Design and Management of Buildings at University of Navarra is an official and bilingual master's degree (Spanish-English), whose objective is to train students in sustainable design and management in the architecture sector, so that they are able to face the complexity of current projects, respecting the deontological and ethical principles that govern the profession. The Environmental Design and Management of Buildings at University of Navarra trains experts in sustainability in buildings, both in the design and in the quantification of the efficiency of the measures adopted. This master's degree was launched in 2010 to respond to the growing demand from companies in the sector for specialists in sustainability in building, not only capable of carrying out energy certifications and audits, but also of designing efficient environmental projects and carrying out lifecycle analyses of the buildings to reduce the impacts that the building produces. **Disciplines:** • Environmental Engineering • Environmental Management • Environmental Sciences • Courses • Management of projects, works and services • Strategy

	• Human factor • Finance • Energy management. Passive measures • Sustainability Principles • Energy and water management. Active measures

9. Fundación Laboral de la Construcción [153]	
Institution status	Private
Course title	Certified Passive House Tradesperson
Type of Training/Course	Vocational
Duration	32 hours
Beneficiaries	Active and unemployed workers in the construction sector
Obtained Diploma/Certificate	Certificate
Description	The objective of this training is to train participants in new techniques and concepts, to master the execution of work under the Passive House Standard. Participants acquire the necessary knowledge to pass the official Passivhaus Institut exam and receive the international title of "Certified Passive House Tradesperson." **Content:** • Interdisciplinary Principles • Passive House Definition • Passive House Criteria • 5 pillars of the Passive House principles • Ecology and comfort • PHPP and other planning principles • Economic Efficiency • Construction process and quality control • User information and user support • Basic Principles: Thermal Insulation in Passive House • Basic Principles: Free Construction of Thermal Bridges • Basic Principles: Passive House Windows • Basic Principles: Hermeticity • Basic Principles: Ventilation • Basic Principles: Heat Supply • Building envelope • Thermal insulation in Passive House • Construction free of thermal bridges • Windows and other transparent exterior components • Comfort in summer • Renovation of existing buildings using Passive House components • Building Installations • Passive House ventilation

	• Heating in Passive House

10. Training centers accredited by the Ministry of Labour, Migrations and Social Security [154]	
Institution status	Private
Course title	Energy Efficiency in Buildings
Type of Training/Course	Vocational
Duration	920 hours
Beneficiaries	Unemployed
Obtained Diploma/Certificate	Certificate
Description	The objective of this training is to: • Assess the energy efficiency of building installations Passive House Criteria • Collaborate in the process of energy certification of buildings • Manage the efficient use of water in buildings • Determine the viability of solar installation projects • Promote the efficient use of energy

11. RENOVETEC [155]	
Institution status	Private
Course title	Energy Efficiency Course in Building and Industry
Type of Training/Course	Vocational
Duration	16 hours
Beneficiaries	Architects, Industrial Engineers, Technical Engineers and professionals in general, interested in Energy Efficiency and in the application of corrective measures and improvement of energy efficiency.
Obtained Diploma/Certificate	Certificate
Description	The objective of the course is to enable the trainee to know the practices, actions and measures that generate energy efficiency in buildings and in industry. Among the topics that are covered by this training: • Building: bioclimatic architecture • Sustainability and sustainable architecture • Bioclimatic architecture • Energy rehabilitation • The energy adequacy of public buildings • Insulation in buildings • Sustainable facilities • Grading systems

	• Energy and regulatory • Recycled • Bioconstruction • Sustainable urban planning

5.1.2.2. Urban Planning Trainings

12. International University of Catalonia [156]	
Institution status	Private
Course title	City Resilience Design and Management
Type of Training/Course	Academic
Duration	1 year-Full Time
Beneficiaries	This program is intended for city practitioners and consultants with at least 2 years of work experience in fields related to sustainability and resilience, as well as university graduates (Graduate Degree or Bachelor's Degree) from the following fields: Planning, Management, Urban Design, Engineering, Environmental, and Social Sciences, Political Science, Geography and Architecture.
Obtained Diploma/Certificate	Master's degree
Description	This Master's degree teaches students how to operationalize the most urgent calls for building more resilient and sustainable cities through urban planning and design, and how to frame adequate policies and governance models. This one-year program provides the most up-to-date perspectives, methods, and tools for dealing with the threat of climate change, natural disasters and the social and technical transformations required to minimize the environmental impact of the current global urbanization trends while addressing social justice. In this master's program, students will bridge science and policy through workshops and active involvement in panel-like classes, fostering different points of view and constantly re-framing the business-as-usual strategies often seen in the creation and management of resilient cities.

5.1.3. Portugal

Buildings represent the third major energy consumption sector with a share of 29% in 2016 (+1.4% than 2006) in Portugal. Despite the increase of the final energy share in national energy consumption balance, the energy consumption trend of this sector has decreased about 15.9% in last 11 years, with a relevant contribution of the residential sector (-19.7% compared to 2006)[157].

Between 2006 and 2016, the residential sector presented a continuous final energy consumption reduction, although after 2014 its consumption has remained almost constant, possibly reflecting a mix of measures in terms of policy implementation and energy efficiency improvement.

The requirement to display an EPC (Energy Performance Certificate) in property advertisements was a major change that contributed to the increase in the number of EPCs issued monthly. The change was not only due to changes in legislation; ADENE (the Portuguese national energy agency) has developed a strategy in order to upgrade the National Building Energy Certification System (SCE), and these changes included the development of a new online platform to issue EPCs, a new EPC layout, a new website, an e-learning platform and the publication of support documentation and guidelines for experts. ADENE's training department provides various training courses about building energy efficiency.

Below is a list of training courses in Portugal that are available: Basic training on thermal performance in building, training of energy audits in residential buildings, training of solar thermal designer, various courses of energy building efficiency under the Energy Performance of Building Directive (EPBD).

5.1.3.1. Energy Efficiency in Buildings Training

13. Agencia para a Energie (ADENE) Academia [158]	
Institution status	Public
Course title	CBTE Module - Basic Concepts of Thermal in Buildings
Type of Training/Course	Vocational
Duration	4 hours
Beneficiaries	All trainees wishing to undergo training on energy performance legislation for buildings (prerequisites: Degree in Architecture or Engineering).
Obtained Diploma/Certificate	Certificate
Description	This training aims to provide designers and architects with knowledge on Basic Concepts of Building Thermals, namely opaque and glazed envelope requirements and on the thermal component of architectural design. This module covers the following topics: • Calculation of superficial thermal transmission coefficients • Determination of linear thermal transmission coefficients • Calculation of loss reduction factors • Calculation of solar factors • Obstruction factor calculation

14. Instituto Politécnico de Setúbal (Polytechnic Institute of Setubal) [159]	
Institution status	Public
Course title	Energy Rehabilitation and Building Conservation
Type of Training/Course	Academic
Duration	2 years
Beneficiaries	Holders of secondary education (regular or professional); Technicians

Obtained Diploma/Certificate	Higher Professional Technical (CTeSP) diploma
Description	The CTeSP in Energy Rehabilitation and Building Conservation trains graduates with skills to intervene in terms of building rehabilitation, conservation and maintenance; implement energy rehabilitation solutions; program and coordinate the execution of small and medium maintenance and maintenance interventions; define technical solutions for rehabilitation and/or conservation, in order to minimize the resources necessary for the functioning of the buildings. It has a total duration of 4 semesters, the first 3 semesters being academic and the last in a real work context (curricular internship). The goal is to train technicians capable of planning, carrying out and coordinating the execution of conservation and maintenance interventions, defining technical solutions for rehabilitation and/or conservation, designing and implementing energy rehabilitation solutions.

15. Sociedade Geral de Superintendência SGS [160]	
Institution status	Private
Course title	Sustainability and Energy Management for Buildings
Type of Training/Course	Vocational
Duration	-
Beneficiaries	Graduate degree holders
Obtained Diploma/Certificate	Postgraduate certificate
Description	To act on the energy situation in Europe, the European Commission created the 2002/91/EC Directive, which imposed the mandatory certification of buildings. In Portugal, this led to the emergence of SCE-Energy Certification and Indoor Air Quality in Buildings. The postgraduate course in sustainability and energy management for buildings enables beneficiaries to: • Develop technical knowledge for comparative analysis, specification and design of passive and active energy systems for buildings • Introduce energy regulations applicable to buildings and opportunities for adapting technologies for local energy production • Develop the expertise to study and analyse the dynamic behaviour of new and existing buildings through the use of the latest tools

	• Develop expertise for further qualifications, such as ADENE (RCCTE, RSECE Energy, RSECE QAI)

16. University of Coimbra [161]	
Institution status	Public
Course title	Specialization Course in Energy for Sustainability
Type of Training/Course	Academic-Professional
Duration	2 semesters-1 year
Beneficiaries	Holders of a degree in the area of Economics, Management, Engineering, Natural sciences, or Architecture
Obtained Diploma/Certificate	Specialized course certificate
Description	The SCESUC is organized in two semesters, allowing each student to obtain 48 ECTS from elective courses. The SCESUC program offers three specialization areas plus a common kernel of general courses. The areas of specialization address energy sustainability at different levels: • **Energy Systems and Policy** In this area, courses are offered to allow students to master topics related with energy and environmental economics, energy markets in various forms of organization and regulation, efficient use of energy and overcoming market barriers, organization of transportation systems for sustainability, among other topics. • **Buildings and Urban Environment** This area builds competences for designing and analysing urban-scale systems, both under a perspective of space organization, at the crossroads of criteria related to the sustainable use of natural resources, functionality, and fruition, and the under a perspective of buildings as complex systems, addressing conception and operation in a context of efficiency, as well as human comfort and health. • **Indoor Climate and Comfort** Besides studying the design and operation of Heating, Ventilation, and Air Conditioning (HVAC) systems, this area sought to improve competences in topics such as analysis of comfort, simulation of energy in buildings, computational analysis of fluid dynamics, or the influence of the buildings' opaque envelope on comfort.

5.1.3.2. Urban Planning Trainings

17. Faculdade De Ciências E Tecnología Universidade Nova De Lisboa [162]

Institution status	Public
Course title	Sustainable Urbanism and Spatial Planning
Type of Training/Course	Academic
Duration	2 years
Beneficiaries	Holders of a 1st cycle, bachelor's degree or master
Obtained Diploma/Certificate	Master's degree
Description	The Master course in Sustainable Urbanism and Spatial Planning aims to: • Combine theoretical concepts and instruments in order to intervening in a sustainable manner in urban areas • Develop capabilities for collecting and processing information using the latest technologies (GIS, Remote Sensing, CAD among other support to the preparation of documents and plans - graphic part) • Develop territorial diagnostic capabilities, urban audits and formulated intervention strategies in a sustainable perspective • Develop and apply innovative methods and effective plan techniques and sustainable management for urban areas • Develop and implement monitoring processes and evaluation of projects, programs and plans.

5.1.4. Italy

In 2018, the energy consumption of the residential sector in Italy was around 34 Mtoe, +19% since 2000 (+1.0%/year). The space heating accounted for 69% of energy consumption followed by electrical appliances with 13%, water heating with 11%, cooking with 6% and air-cooling with 1%. The end-use consumption had an increasing trend: +1.2%/year for space heating, +1.4%/year for cooking, +9%/year for air-cooling and +0.6%/year for electrical appliances. The percentage distribution of end-use consumption was practically constant in the last 10 years. Energy consumption of electric appliances amounted to 0.18 toe/dwelling in 2018, -3.8% since 2000 and -11.5% since 2011, mainly due to progress in energy efficiency [31].

"*Improving the energy performance of buildings is one of the main objectives to accompany the energy transition of our country with significant economic benefits: energy requalification interventions, in fact, have generated about 39 billion euro of investments and 270 thousand jobs in the last 10 years each year, which reach over 400 thousand considering also related activities*," Ilaria Bertini, head of the ENEA Energy Efficiency Unit Department pointed out.

5.1.4.1. Energy Efficiency in Buildings Training

18. Università Degli Studi Di Genova [163]	
Institution status	Public
Course title	Engineering for Building Retrofitting

Type of Training/Course	Academic
Duration	2 years
Beneficiaries	Bachelor's degree holders in one of the following fields: Civil Engineering, Environmental Engineering, Building Engineering, Architecture, Industrial Engineering.
Obtained Diploma/Certificate	Master of Science degree
Description	Engineering for Building Retrofitting addresses the topic of the protection, rehabilitation, and enhancement of the existing buildings in terms of structural safety, energy efficiency, quality, and comfort, considering social and economic issues. This two-year program, taught entirely in English, tackles the specific issue of the rehabilitation of existing buildings with a multi-sectoral integrated approach. The program trains engineers to be able to assess and rehabilitate existing buildings, rather than design new ones. It is focused on the following main learning areas: • structures • energy and plants • quality and comfort. Furthermore, it includes some supplementary classes in the field of digital survey and representation, economic valuation, project financing, project and building site management. The beneficiaries will learn a number of skills through this master's degree: • Energy performances: To assess the energy performances of existing buildings. • Structural and seismic safety: To assess the structural and seismic safety of existing buildings. • Building quality and comfort: To assess the state of maintenance and the comfort of existing buildings. • Structural retrofitting interventions: To diagnose an existing building and to design safety and retrofitting interventions. • Increase energy efficiency: To define strategies and design interventions to increase the energy efficiency of existing buildings. • Enhance building quality and comfort: To design maintenance interventions and to improve the comfort in existing buildings.

5.1.4.2. Urban Planning Courses

19. Politecnico di Torino [164]	
Institution status	Public
Course title	Territorial, Urban, Environmental and Landscape Planning

Type of Training/Course	Academic
Duration	2 years
Beneficiaries	Holder of Bachelor's degree
Obtained Diploma/Certificate	Master's degree
Description	The Territorial, Urban, Environmental and Landscape Planning programme at Politecnico di Torino delivers training for spatial planners, capable of solving complex problems associated with the present and future of cities and territories: environmental sustainability, energy efficiency, mobility, social inclusion, climate change, land take reduction, landscape and heritage preservation. The training offers knowledge in three main disciplines: • Landscape Architecture • Environmental Sciences • Urban planning In addition to the different disciplines, the program provides two curricula options in Italian and English: • Urban and Regional Planning (in Italian) • Planning for the Global Urban Agenda (in English)

5.1.5. France

According to the French ministry of ecological transition, the building sector in France occupies 44% of the consumed energy making it the largest consumer of energy of all the economic sectors. The building sector is responsible for more than 123 million tons of CO_2 per year, which makes it a significant area to fight climate change as well as an attractive field for energy efficiency-related investments. [165]

The French government efforts to make the best use of the building sector in terms of energy efficiency, especially in both the new and existing buildings, lie in setting up three mechanisms: regulatory, awareness-raising and incentive.

France aims through the regulatory mechanism to cut the energy consumption both in a progressive and significant way, to control rents and charges the best way possible, and thus facilitate access to housing and finally to ban the less satisfactory products, systems and practices. Concerning the awareness mechanism, the government of France intends to inform users about their energy consumption and the energy performance of the premises they occupy in addition to the promotion of an eco-citizen behaviour. The last mechanism comprises two objectives, first to encourage the construction of the buildings of the future today, as well as to bring about the ultimate energy efficiency enhancements in the already existing buildings by providing financial support for the households to purchase the most efficient materials and equipment, in addition to using renewable energies.[165]

To achieve carbon neutrality by 2050, as part of France's energy and climate policy, three areas need to take advantage of in buildings: reducing the energy needs of buildings, using efficient systems to limit energy consumption, and finally, the deployment of renewable energies. Thus the growing demand for professionals and workers in this field, as a result, many governmental

and private institutions are providing training, courses, and degrees in disciplines related to energy efficiency, bioclimatic building, and urban planning.[166]

The following are some of the trainings provided by both private and public entities.

5.1.5.1. Energy Efficiency in Buildings Training

20. L'Université Claude Bernard Lyon [167]	
Institution status	Public
Course title	Civil engineering Course: High energy efficiency building
Type of Training/Course	Academic and Professional
Duration	4 semesters (240 hours)
Beneficiaries	1st Year Master's degree students and Engineering school students
Obtained Diploma/Certificate	Master's degree
Description	M2 training is organized over 2 semesters with university teaching (courses, tutorials and practical work) and a long internship in a professional environment (16 weeks). The lessons are partly shared with other courses. The speakers are both professionals (design offices, technical centers, large companies) and teaching researchers. In the context of raising the energy performance levels to be achieved for new and rehabilitated buildings, the aim of this specialization is to train, at master's level (High school Diploma + 5), technical building managers capable of partaking in the design and the evaluation of high energy efficiency constructions. The training focuses on the use of digital simulation tools for the dynamic design of the envelope and technical systems, as well as on energy renovation.

21. La Rochelle University [168]	
Institution status	Public
Course title	Civil engineering building engineering course: management and integration of energy efficiency and renewable energies "IB-GI3ER"
Type of Training/Course	Academic
Duration	4 semesters
Beneficiaries	Students with bachelor's degree (3 or 4 years) or equivalent with knowledge of civil engineering
Obtained Diploma/Certificate	Master's degree
Description	The aim of this academic course is to enable students to design, organize and supervise all the stages of a building project particularly in the management and integration of energy efficiency and techniques using renewable energies (GI3ER course).

	Among the main courses taught in this course: • Building energy • Energy production • Hydraulic networks and mechanical ventilation • Efficient design of enclosures and systems • Integrated building design The beneficiary will also be trained in management, communication and interpersonal skills.

22. École des Mines de Saint-Étienne [168]	
Institution status	Public
Course title	Energy Efficiency in Building Renovation
Type of Training/Course	Academic
Duration	1 year
Beneficiaries	The beneficiary must hold one of the following levels of diplomas and/or experience: An engineer title (generalist or specialist); An architectural diploma; A technical or scientific Master 2; A technical or scientific Master 1 coupled with 3 years of professional experience in the building industry.
Obtained Diploma/Certificate	Specialized Expert Master
Description	The Specialized Expert Master's degree in Energy Efficiency in the Renovation of Buildings (MS EERB) has been initiated to address energy, environmental, economic and socio-technical issues in a multidisciplinary manner, the training aims to deploy new players in renovation. The Specialized Master Expert in Energy Efficiency in Building Renovation (MS EERB) label was adopted from careful reflection on the needs of building stakeholders as well as from the active observation carried out by the School of mines on the energy theme. A merger with the SIEMENS company and the analysis of energy issues and ambitions in Europe and France have imposed on the School the theme of energy efficiency in the renovation of buildings as a key development factor and element that will enable the creation of added value. **4 Modules are taught in the EERB MSc degree:** • Existing building, characteristics, specificities and regulations • Technical systems and optimization • Economic, environmental and social approaches to a project • Management, simulation and professionalization

23. WEDGE Institute [169]	
Institution status	Private Center
Course title	Expert in Economics and Energy Efficiency of Buildings
Type of Training/Course	Professional
Duration	41 days
Beneficiaries	The beneficiary must master the basics of building thermics
Obtained Diploma/Certificate	Individual DPE certification (optional) Certificate of Competence
Description	The training in energy efficiency in buildings is placed at the core of the current environmental problem and offers any professional who so wishes, with prior knowledge in building thermic, to obtain a certificate of competence, or even an optional level diploma. High School Diploma + 5, recognized by the RNCP, supplemented by a possible DPE certification. The training covers theoretical class, practical work, land, thermography day and infiltrometry. **Training purposes:** • Learn how to carry out the energy audit of buildings according to the new standards (NF EN 16247-1 and NF EN 16247-2) and carry out the thermal study of the new building, in accordance with RT2012 • Establish an energy diagnosis/audit of the existing • Advise and assist the client with a view to establishing the application for the BBC/BBC renovation label • Advise and assist the client in order to optimize the energy performance of both new and existing • Establish work recommendations in accordance with the technical specifications: work planning, cost control and calculation of returns on investment, financing mechanisms, tax benefits • Establish a provisional thermal balance according to the choice of works selected • Master the different calculation methods (3CL/THce ex, Th C-E, Th Bât calculation rules, Th-BCE 2012 method and Bbio coefficient • Acquire Knowledge of the general principles of thermography and infiltrometry • Check the building's compliance with RT2012 and validate a project with regard to the labels (HPE, THPE, BBC-Effinergie, BEPOS, etc.).

5.1.5.2. Urban Planning Courses

24. Urban Planning Institute and Regional Planning (IUAR - Aix-Marseille University) [170]	
Institution status	Public
Course title	Urban Planning and Development: • Specialization in -Housing, city policy and urban renewal • Landscape and landscaping specialty • Specialization in sustainable urban planning, project and operational action
Type of Training/Course	Academic
Duration	2 years or over
Beneficiaries	Students with a Bachelor's degree
Obtained Diploma/Certificate	Master's degree (Specialized)
Description	The "Urbanism and Development" master's degree is considered the heart of the training provided by the Institute of Urbanism and Regional Planning since 1969. It is known by its multidisciplinary teaching, the importance given to teamwork and partnership with the professional community. It is part of the professional charters of the Ministry of Sustainable Development, the Professional Office for the Qualification of Town Planners (OPQU), as well as that of the Institutes of Town Planning and Development at the French level (APERAU) and European Union (AESOP). The diploma is also recognized by the Société française des urbanistes (SFU). The aim of the master's degree is to introduce students to all the concerns and the different aspects of the urban planning occupations today. The course represents a mix of theoretical approaches, specialization courses, project workshops in semi-professional conditions and internships.

25. Institut d'Aménagement des Territoires, d'Environnement et d'Urbanisme de l'Université de Reims (IATEUR) [170]	
Institution status	Public
Course title	Sustainable urbanism and development
Type of Training/Course	Academic
Duration	2 years
Beneficiaries	Professionals, urban planners and developers
Obtained Diploma/Certificate	Master's degree
Description	Taught within the IATEUR (Reims Institute of Regional, Environment and Urban Planning), the master trains urban planners and developers, with a view to sustainability. It

	emphasizes the environmental dimensions of planning policies and aims to better understand the complexity of the fields and techniques of sustainable urban planning. For this, the courses underline, on the one hand, the new fields of action induced by contemporary evolutions and the development of new tools and, on the other hand, allow students to acquire a good knowledge of decision-making systems and governance logics. **• The training offers 2 thematic specializations during the 2nd year:** • Temporal urbanism and chronotropic approach to the city; • 2Rural development: reconfiguration of agro-urban spaces. The ITEUR's Master in Sustainable Urbanism and Development aims to train urban planners and developers. It emphasizes the sustainable dimensions of planning policies. It is therefore a matter of training professionals capable of understanding the issues specific to a region, in order to provide effective and sustainable responses. The Master in Sustainable Urbanism and Development is based on the search for a new balance between teaching which revisits the models of action which urban planners have hitherto resorted to, and teaching offering a capacity to fit into the complexity of fields and techniques of sustainable urban planning. Professional skills cover the acquisition of analytical, decision-making, management and proposal skills.

26. Institute of Geo Architecture (Brest) [171]	
Institution status	Public

Course title	• Sustainable Development and Urbanism, Environment" (AUDE)
	• Sustainable Planning and Urbanism, Environment (AUDE):
	  ○ Urbanism and Development Specialization
	  ○ Environment and Planning Specialty

Type of Training/Course	Academic
Duration	1 year for both degrees
Beneficiaries	The beneficiary must have a level of study of 2 years after high school Diploma
Obtained Diploma/Certificate	Bachelor's degree Master's degree (Specialized)
Description	**3rd year bachelor's degree:** The DSUPE/AUDE course (Development and Sustainable urban planning, Environment) is designed to specialize, in the 3rd year of the Bachelor degree, higher studies started in one of the many

	disciplines involved in planning or the environment, in Bachelors, DUT or BTS: architecture, biology, law, economics, geography, civil engineering, earth sciences, sociology. The AUDE 3rd year Bachelor degree offers a multidisciplinary approach characteristic of the professions for which urban planning institutes prepare. It respects the agenda defined in partnership with the Professional Office for the Qualification of Town Planners. Classes and fieldwork are designed for small groups, which provide the opportunity to gain knowledge and skills necessary in understanding and transforming areas that are urbanized or to be preserved. **Specialized 2nd year master's degree:** In this master's, there is a common class and an option from which the student can choose. The common class covers the economic, legal, social and environmental knowledge necessary for all planning professions. The transformation of urban spaces, like the organization of non-urbanized spaces, now supposes a versatility of professionals, who must exhibit skills in many specialties. **The optional courses are dedicated to:** • The theories and practices of production in the urbanized environment, and the relationship it maintains with the development of its territory; • Taking the environment into account in regional planning.

5.1.6. Austria

Austria's government has pledged to attain carbon neutrality by 2040. This decision will necessitate Austria to significantly enhance de-carbonisation efforts across all energy sectors.[172]

Austria's emissions growth since 2014 is predominantly driven by the increase in final energy consumption in buildings and transport. The government plans to phase out oil- and coal-fired heating systems by 2035, and to restrict the use of natural gas for heating in new buildings by 2025.[172]

The ambitions set by the Austrian government require professional and academic training in the field of energy efficiency, bioclimatic buildings and urban planning. Presented below are several courses, training, and degrees offered by the public and private institutions in Austria.

5.1.6.1. Energy Efficiency courses

27. University of Applied Sciences Technikum Wien (Technikum Wien) *[173]*	
Institution status	Public
Course title	Urban Renewable Energy Technologies
Type of Training/Course	Academic

Duration	6 semesters
Beneficiaries	Technicians & Engineers
Obtained Diploma/Certificate	Bachelor's degree
Description	The Urban Renewable Energy Technologies bachelor's degree program is at the interface between energy technology, technical building systems, and plant construction. Students receive technical-engineering training with an emphasis on energy systems increasingly characterized by renewable energies (especially in urban environments). The degree program provides technical and non-technical subjects and an in-depth knowledge on the functioning and operational behavior of renewable energy technologies, on the dimensioning of technological components, and on their integration into the overall system. Students learn to: • Plan, dimension, operate, analyze, and maintain renewable energy technologies while taking into account technical as well as financial aspects • Integrate complex energy systems into the overall energy system, particularly in urban areas • Assess these systems from technical, environmental, and financial perspectives • Analyze problems in connection with energy, buildings, and domestic engineering, and develop technical solutions for these problems • Rate buildings from an energy perspective, do calculations for energy performance certificates, and determine and simulate heating loads, cooling loads, and annual energy requirements • Plan, perform calculations for, and assess technical building services with regard to their integration into the overall system • Analyze and assess the urban energy supply, boiler plants for district heating systems, combined heat and power plants, and energy distribution networks with regard to their integration into the overall system, design their main components, and operate and maintain them • Analyze the links between various individual fields of energy technology, plant construction, and technical building systems in a smart city environment, and combine these fields to form an intelligent, carbon-neutral, and user-friendly overall system

28. Danube University Krems (Donau-Universität Krems) *[174]–[177]*	
Institution status	Public

Course title	Building Innovation
Type of Training/Course	Academic/Professional
Duration	MEng 5 Semester, part time including: • Certified Program Building Physics and Building Simulation (2 semesters) • Certified Program Building Technology – HKL (2 semesters) • the Building Automation Certified Program (1 semester)
Beneficiaries	Building physicists, Technical planners TGA or MSR, Civil engineers, Architects, Civil engineers, Property developers, Executors in the construction industry, Builders, Facility managers, Teachers of relevant subjects and Those interested in future-proof building planning
Obtained Diploma/Certificate	Master of Engineering degree Certificate for Certified Program Building Physics and Building Simulation Certificate for Certified Program Building Technology – HKL Certificate for the Building Automation Certified Program
Description	The part-time course "Building Innovation, MEng" provides innovative education in the field of resource-saving, sustainable building planning. Students benefit from the knowledge and experience of the experts in the fields of integral planning, structural physics, technical building services, building simulation, circular economy in above-ground construction, building automation, monitoring, and building information modelling. **The "Building Innovation, MEng" course consists of the following modules:** • Module 1: Climate protection and holistic quality of buildings • Module 2: Building Physics • Module 3: Building Physics • Module 4: Energy-efficient comfort solutions and building simulation • Module 5: heating, air conditioning, ventilation • Module 6: heating, air conditioning, ventilation • Module 7: heating, air conditioning, ventilation • Module 8: Building Automation • Module 9: Building Automation • Module 10: Building simulation • Module 11: Resource storage buildings - circular economy in building construction • Module 12: BIM in building construction The course contains as well the following certified programs:

	Module 2 - Module 4 form the Certified Program Building Physics and Building Simulation The university course “Building Physics and Building Simulation” is a part-time training program with the aim of providing practical and technically oriented training in the field of building physics planning of sustainable and energy-efficient buildings. The aim of the course is to train specialists from the technical building environment (target group: Building physicists) in particular in the field of building and energy technology and thus to meet the high need for further training in this field of activity. **Module 5 - Module 7 form the Certified Program Building Technology – HKL** The university course "Building Technology - HKL" is a part-time further training offer with the aim of creating practical and technically oriented further training in the field of technical planning of sustainable and energy-efficient buildings. The aim of the course is to train specialists from the technical building environment in particular in the field of building and energy technology and thus to meet the high need for further training in this field of activity. **Module 8 - Module 9 form the Building Automation Certified Program** The university course "Building Automation" is a part-time training program with the aim of creating practical and technically oriented training in the field of building automation for sustainable and energy-efficient buildings. The aim of the course is to train specialists from the technical building environment in particular in the field of building and energy technology and thus to meet the high need for further training in this field of activity.

29. University of Applied Sciences for Management & Communication FHWien der WKW / WIFI ÖSTERREICH*[178]*	
Institution status	Public
Course title	Integrated Facility and Energy Management
Type of Training/Course	Academic/Professional
Duration	As part of the Academy for Continuing Education in Integrated Facility and Energy Management, students can choose a program with the duration of: 4 semesters (awarded a Master of Science) or

	2 semesters (awarded the title Academic Expert).
Beneficiaries	Experts in construction engineering, building services or electrical engineering. The program is for people who need to develop their management skills alongside their technical expertise, due to changes in legal requirements and technical innovations.
Obtained Diploma/Certificate	Master of Science (4 semesters) Awarded the title of Academic Expert (2 semesters)
Description	The education degree program in Integrated Facility and Energy Management allows students to develop their management and coordination skills as well as specializing and developing their skills in construction and power engineering. This enables them to solve problems, which interface construction systems and energy systems and coordinate different interest groups and or unions. The continuing education program in Integrated Facility and Energy Management is geared towards people with comprehensive subject-relevant experience in construction engineering and/or energy systems in new and refurbished buildings with a basic knowledge of business. The continuing education program offers the opportunity for students to attain a qualification at university level and is a successful combination of compact, theoretically sound training and a practice-based education. Graduates will have many opportunities for demanding jobs in integrated facility and energy management, as future ecological and sustainable projects and concepts can only function well if there is a balance between building, people and energy supply. The program contains the following modules: • Trends and developments in construction and energy • Integrated planning and project management • Building and construction • Thermodynamics • Electrical Power Engineering • Building physics and building ecology • Heating, sanitary, ventilation and air conditioning technology: • Heating and plumbing technology • Ventilation systems and air conditioning • Thermal energy supply • Electricity supply of energy • Energy technology application project • Sustainable energy concepts in construction • Legal framework for construction projects • Management of construction projects

	• Economic framework conditions for construction projects • Application project renovation or new construction • Integral planning and construction supervision The continuing education program in Integrated Facility and Energy Management is offered in two formats: • As a 2-year continuing education Master completed with the title “Master of Science (MSc) Integrated Facility and Energy Management”, or • As a 1-year certificate degree program completed with the title “Academic Expert for Integrated Facility and Energy Management”

30. Salzburg University of Applied Sciences / Fachhochschule Salzburg*[179]*	
Institution status	Public
Course title	Smart Building: Energy Efficient Building Technology & Sustainable Construction
Type of Training/Course	Academic
Duration	6 semesters
Beneficiaries	Engineers & Technicians
Obtained Diploma/Certificate	Bachelor of Science in Engineering (BSc)
Description	The Bachelor's degree in Smart Building combines the basic principles of construction and engineering with the innovative approach of energy-efficient building technology. The focus is on sustainable construction, holistic perspectives, and efficient use of energy and costs. Students will learn how to design buildings of the future that can be used as work and living spaces. Theoretical and practical knowledge in constructive construction, building technology, and in the field of energy and information technology will help achieve this. This course trains to focus on people and the environment. In addition to dealing with natural resources responsibly without losing sight of economic aspects. Among others, the following aspects form part of the bachelor’s degree in Smart Building: • Sustainable architecture • Engineering and natural sciences • Construction and building technology • Energy and information technology • Social-communicative and economic aspects • Courses taught: • Ecology / sustainable building • Smart building • Building physics • Building theory / GL building construction theory / statics

	• Descriptive Geometry / Engineering Drawing and CAD • Physics and Thermodynamics • BIM - Building Information Modeling • Technical building equipment • Energy technologies • Integrative project • Life cycle assessment / life cycle costs • Selected chapters building physics • Integrated building structures • Information and communication technology / building automation systems • Construction management / legal theory • Control and regulation technology / building technology applications • Building simulation • Scientific work / project development • Internship • Specialization in Smart Building Systems • Smart Building Systems I • Building automation • Specialization in Smart Building Constructions • Smart Building Constructions I • Climate-friendly building and design • Building certifications (2 out of 3 selectable): • Passive house planner • Energy advisor • Certification systems

31. E-genius Initiative offene Bildung (Open education initiative in technology and natural sciences) *[180], [181]*	
Institution status	Funded by private and public entities
Course title	Building renovation Building materials and facade systems
Type of Training/Course	Free online training and self-study courses
Duration	Self-Paced
Beneficiaries	Mixed: Anyone interested in the courses offered for free
Obtained Diploma/Certificate	None
Description	E-genius Initiative offene Bildung is an Open education initiative in technology and natural sciences. The initiative offers practice-related learning units (learning fields), case studies, online courses, images and videos, a glossary of technical terms as well as exercises (quizzes) and suggestions for students and teachers. Thermal and energetic building renovation course:

	A renovation rate of 3% per year would be necessary to achieve the Paris climate targets. In this subject area, we deal comprehensively with the subject of thermal and energetic renovation as well as highly efficient renovation. Essential areas you find in the Thermal and energetic building renovation course: Thermal-energetic building renovation – introduction Building condition analysis Thermal-energetic building renovation - component renovation The Building materials and facade systems course: Sustainable and energy-efficient building materials are becoming more and more important. Traditional, sustainable building materials such as clay, but also conventional and so-called "intelligent" building materials will be presented. Different insulation materials and facade systems in wood and solid construction are also discussed. Essential areas you find in the building materials and facade systems course: • Insulation materials – properties • Insulation materials – processing • Insulation and facade systems in timber construction • Insulation and facade systems in solid construction • Insulation and facade systems - interior insulation

32. E-genius Initiative offene Bildung (Open education initiative in technology and natural sciences)*[182]*	
Institution status	Funded by private and public entities
Course title	Energy-efficient building concepts
Type of Training/Course	Free online training and self-study courses
Duration	Self-Paced
Beneficiaries	Mixed: Anyone interested in the courses offered for free
Obtained Diploma/Certificate	None
Description	The EU directive on the overall energy efficiency of buildings (EPBD) stipulates that, among other things, minimum requirements for technical building systems must be met in future and that the new buildings must meet the standard of a "zero-energy building". This topic deals with essential areas of energy-efficient construction. Essential areas you find in the Energy Efficient building concepts course: • Energy efficiency in buildings • Net Zero Energy Building • The passive house • Plus energy building

	• Plus-energy settlement • Solar thermal heated buildings • Innovative building concepts • Sustainability and climate protection in the construction sector • Ecological assessments and life cycle thinking • Energy saving potential in the building • Room climate and comfort in the passive house • Thermal comfort • Introduction to building technology • Controlled living space ventilation with heat recovery

33. FH Burgenland / University of Applied Sciences Burgenland*[183]*	
Institution status	Public
Course title	Building technology and building automation
Type of Training/Course	Academic
Duration	6 semesters
Beneficiaries	Specialists who are involved in the planning, installation or on-going operation of technical facilities in buildings
Obtained Diploma/Certificate	Bachelor of Science in Engineering degree
Description	The aim of the bachelor's degree is to train specialists who are involved in the planning, installation or ongoing operation of technical facilities in buildings. The main goal is to create cozy and comfortable ambient conditions for the users of a building and to be as energy-efficient, resource-saving and ecological as possible. Courses taught : Natural and engineering sciences, engineering, sustainable building Building technology: heating, ventilation, air conditioning and sanitary technology; Optoelectronics and lighting technology Building automation: building mechatronics, measurement, control, regulation and control technology

34. FH Burgenland / University of Applied Sciences Burgenland*[184]–[186]*	
Institution status	Public
Course title	Building technology and building management
Type of Training/Course	Academic/Professional
Duration	4 semesters of technical studies
Beneficiaries	Building technicians and building managers
Obtained Diploma/Certificate	Master’s degree

Description	The aim of the Master's course is to train building technicians and building managers who, due to their knowledge, method and action skills, are able to face current and future challenges in the industry, such as to be able to master the implementation of "integral planning using Building Information Modeling" and the "Nearly Zero Energy Buildings Standard". The Master's degree will allow the beneficiaries to learn the necessary skills for planning, setting up, operating and maintaining energy-efficient and cost-efficient technical building systems for residential and non-residential buildings The course, which was founded in 1994, convinces with experts in teaching and the opportunity for applied research and development in the well-equipped laboratory directly in the study center. The curriculum combines content such as technical building equipment, building management, BIM as well as regulation and control technology with business law and security. The course is unique in Austria due to its specialization options in the field of building technology and building management. Occupational fields: After graduation, graduates work in companies and organizations that work in the areas of planning, construction, Renovation operational and maintenance optimization of buildings and building services systems are active. In particular includes the professional field in the following areas: Among the courses taught we find: • Basic module building technology • Gas and sanitary technology • Installation technology water • Gas application technology • Energy distribution and system hydraulics • Power distribution • System hydraulics specialization • Dynamic modelling • Ventilation technology • Refrigeration and heat pump technology • Electrical installation technology • Lighting technology • Photovoltaics • Acoustics specialization • Measurement technology specialization • Construction technology and use of solar energy • Thermal building and system simulation • Building Information Modeling - building technology

	• Strategic building management • Life cycle cost management

35. Energie Tirol*[187], [188]*	
Institution status	Non-profit association
Course title	Basics of Energy consulting (A-course)
Type of Training/Course	Professional
Duration	-
Beneficiaries	Employees of planning and executing companies in the field of construction and building services People who work or want to be active in the construction sector in an advisory capacity. Community workers
Obtained Diploma/Certificate	Certificate
Description	The current climate protection discussion is increasingly focusing on the subject of energy efficiency and the use of environmentally friendly alternative energies. Planners are confronted with questions about the choice of building standard, environmentally friendly heating systems and the energy savings that can be expected. With the course, the participants receive basic training in planning energy-efficient buildings in the field of construction and building services. The training of Energie Tirol follows the guidelines of the Arbeitsgemeinschaft Energieberaterausbildung (ARGE EBA) and is divided into a basic course (A course) and a continuation course (F course). Participants receive the basic training for planning energy-efficient buildings in the field of construction and building services. The content of the course is as follows: • Planning principles for energy-efficient building • Insulation materials, insulation thickness • Redevelopment • Thermal bridges • Vapor diffusion • Air and wind density • Mold • Building technology in general • Hydraulics, distribution • Solar energy • Heat pumps

	• Comfort ventilation • Biomass

36. Energie Tirol*[189]*	
Institution status	Non-profit association
Course title	Energy consultant (F-course)
Type of Training/Course	Professional
Duration	-
Beneficiaries	Employees of planning and executing companies in the field of construction and building technology with relevant professional training as well as everyone who has completed the A course and wants to qualify for a job as an energy consultant. Engineers, Technicians and consultants
Obtained Diploma/Certificate	Certificate
Description	Building on the course “Basics of Energy Consulting (A course)”; The focus is particularly on special topics of energy-efficient construction and renovation. The training enables you to provide competent energy advice, to draw up renovation concepts, energy certificates * and much more. The content of the course: • HWB in the energy certificate • Building services in the energy certificate • House of the future • Cost-optimized building • RL6 • Rehabilitation in protection zones • Ecology in construction, OI3 index • Air and wind tightness - deepening • Thermal bridges and • Vapor Diffusion - Deepening • Thermography • Mold • Technologies for the energy strategy • Photovoltaics and storage • Comfort ventilation - deepening • Hydraulics and heat distribution • Storage masses, component activation, overheating in summer • Climate active heating systems • Building rating systems • Funding - deepening

	• Subsidy-optimized construction and renovation • Building book • Economy

37. Energy Institute Vorarlberg*[190]*	
Institution status	Non-profit association
Course title	Energy consultant training (A course)
Type of Training/Course	Professional
Duration	-
Beneficiaries	Employees of planning companies, technical offices, authorities or municipal administrations. Employees in the main construction or ancillary construction trades, consultants in specialist stores, Customer advisors from energy supply or energy service companies, Members of e5 teams, people who work or want to be active in the construction sector in an advisory capacity.
Obtained Diploma/Certificate	Certificate
Description	The newly designed basic energy consultant course will help participants acquire all the necessary basics on the subject of "energy-efficient building and renovation". They will learn the basics of building physics and calculate the most important parameters such as U-value and heating load. Of course, the building services, electricity applications, costs and economy are not neglected either. The part-time energy consultant basic course (A course) provides the necessary specialist knowledge for future energy consultants. It is aimed at anyone who is already or would like to work in the field of “energy-efficient building and renovation”. In theory and practice, the basics of planning and building standards, calculation methods, requirements, influencing variables and implementation variants for an energy-efficient building envelope, ventilation and heating technology are conveyed. Our speakers make the transfer of knowledge varied and as interactive as possible. The topics covered are applied directly in practical exercises, such as an airtightness test in the seminar room or arithmetic exercises. The following topics are dealt with in depth: • Planning principles • Structural engineering and building physics basics, building materials and component constructions • Ventilation technology and airtightness test • Hot water preparation and distribution

	• Heat distribution and regulation • Profitability, building analysis, subsidies • Working methodology in energy consulting, communication • The course follows the guidelines of the Working Group on Energy Consultant Training (ARGE EBA) and comprises 50 units (including 4 units of literature research). It concludes with a written exam.

38. MCI Unternehmerische Hochschule/ MCI | The Entrepreneurial School*[191]*	
Institution status	Privately organized business school
Course title	Smart Building Technologies
Type of Training/Course	Academic
Duration	6 semesters
Beneficiaries	Students with: A university entrance qualification (e.g. Matura, relevant university entrance qualification, vocational qualification). Without a university entrance qualification but with relevant professional qualification (Engineers, Technicians…), provided that one of the following prerequisites is also met: successful completion of a relevant, vocational secondary school or Successful completion of a dual training program in relevant apprenticeships.
Obtained Diploma/Certificate	Bachelor of Science in Engineering
Description	The program Smart Building Technologies course offers students a well-founded education in the field of building services engineering. The course of studies is offered in dual form. This means that several months of study at the university are followed by several months of experience in the field within innovative partner companies. In this way, theory and practice are continuously linked and students gain relevant work experience during their studies. In particular, the study program focuses on the fields of automation and information technology, the vast field of heating, air conditioning, ventilation and sanitary engineering, as well as lighting technology and therefore the deriving "human" component of well-being in rooms. The dual study program focuses on the development of technical solutions for relevant, future-oriented challenges arising from the subject area of an increasingly digitalized building technique. The technical components are consolidated with courses in the fields of economics, management and social skills. Among the modules taught in the program we find:

	• Scientific & Technical Basics • Engineering Sciences • Information Technology • Automation& Measurement, Control & Regulation • Heating, Ventilation, Air Conditioning & Sanitary Engineering • Comfort in Services Engineering • This qualified and interdisciplinary education enables graduates to work in a wide range of professions, such as: • Building Design & Planning • Building automation • Water Supply & Water Disposal • Heating, air conditioning, ventilation and sanitary technology • Sun & weather protection • Lighting technology

5.1.6.2. Urban Planning courses

39. University of Applied Sciences Technikum Wien (Technikum Wien)*[192]*	
Institution status	Public
Course title	Renewable Urban Energy Systems
Type of Training/Course	Academic/Professional
Duration	4 semesters- part time
Beneficiaries	Technicians & Engineers
Obtained Diploma/Certificate	Master's degree
Description	Renewable Urban Energy Systems is a part-time master's degree program for energy systems of the future. It focuses on complex issues related to energy technology and the energy business. This degree program is taught in German. The degree program is intended for graduates of the Urban Renewable Energy Technologies bachelor's degree program and graduates of other technical UAS and university programs. Students learn to: Analyze complex issues related to energy systems and individual plants, cities, or districts and develop solutions Analyze energy-efficient, sustainable, and complex energy systems and develop concepts for optimal use of different energy sources Propose measures for adapting existing grids (heating, cooling, electricity) for integration into decentralized production plants and ensure a high security of supply and supply quality

	Analyze different storage technologies and illustrate their integration into power grids with the right dimensions and with all essential technical system-related measures Describe environmental relationships as they relate to energy topics, illustrate the impact of anthropogenic interventions in energy systems, and select measures to limit impact Develop a supply-side and demand-side management system for an energy system (electricity, heating/cooling, natural gas) Optimize the use of different production plants according to economic and environmental aspects Develop and use measures to increase the efficiency of plant components, especially components of thermal energy systems Analyze existing energy systems and develop concepts for optimal use of different energy sources Quantify the impact of renovation measures in buildings on the energy system as a whole. The main courses taught In the master's degree are as follows: • Control Technology (M11) • Ecology, Energy and Society (M15) • Energy Storage (M12) • Energy Systems: Modelling and Simulation (M13) • Innovation and Investment (M16) • Introduction into Modelling and Simulation (M14) • Digital Systems in the Energy Industry (M22) • Energy Concepts and Evaluation Procedure (M21) - • Energy Industry (M25) • Energy Systems: Concepts and System Development (M23) • Energy Systems and Aspects of System Integration (M24) • Energy Systems: Holistic System Development and Interdisciplinary Assessment (M33) • Energy and Environmental Law (M35) • Process Optimization and Assessment (M31)

40. Salzburg University of Applied Sciences*[179], [193]*	
Institution status	Public
Course title	Smart Buildings in Smart Cities- Energy Infrastructure and District Renovation
Type of Training/Course	Academic
Duration	4 semesters/part time

Beneficiaries	Students and anyone with the following qualifications: A relevant university degree (bachelor's or master's degree in technology) or an equivalent degree from a post-secondary educational institution Proof of ECTS credit points in the core subject areas required for the master's degree Mastery of the German language (level B2), good knowledge of English (teaching partly in English)
Obtained Diploma/Certificate	Master's degree
Description	The Master's degree in Smart Buildings in Smart Cities provides the participants with comprehensive basic and practical specialist knowledge in the areas of building and urban and neighbourhood development. Pollution, population changes, resource scarcity – smart cities and buildings can make significant contributions to solving all of these problems. The aim of the Master's programme "Smart Buildings in Smart Cities - Energy Infrastructure and District Renovation" is to meet the needs of increasingly networked-thinking engineers in the fields of building and district renovation and integrated energy systems. In doing so a special focus is put on the interaction between technology and energy with regards to nature, people and the environment. During the first year of studies at Salzburg University of Applied Sciences, the focus will be devoted to understanding and responding. Bridging people, nature, and the environment. In the second part of the Master's degree, participants will be able to choose one of two main areas: Integrated energy systems– renewable energy systems, storage technologies, and smart grids; networking all consumer structures in a city Building and neighborhood renewal– energetic building and neighborhood renovation; technical, demographic, economic, urban, and economic issues Among the courses taught in this program we find: • Architecture and Building Culture • Demographic Change and Social Transformation • Ecosystem City • Environmental Resources • Ethics and Sustainability • Integrated Environmental Simulation

	• Open Space Planning • Smart Cities 1: Basic principles • Smart Cities 2: Dimensions • Sociology in an Urban Environment • Spatial Planning • Urban Development • Energy Related Consumer Structures • Fundamentals of Energy Infrastructure • Integral and Cooperative Planning Processes • Integrated Module, Residential Area concepts • Buildings and Urban Regeneration • Integrated Energy Systems

41. E-genius Initiative offene Bildung (Open education initiative in technology and natural sciences)*[194]*	
Institution status	Funded by private and public entities
Course title	Urban development
Type of Training/Course	Free online training and self-study courses
Duration	Self-Paced
Beneficiaries	People who want to change something in their city / neighborhood and who want to work together on specific problem solutions.
Obtained Diploma/Certificate	None
Description	The urban development field focuses on the subject of Helping shape the city - with Living Labs to improve the quality of life in cities. The instruction “Shaping the city - with living labs for a better quality of life in cities” is aimed at people who want to change something in their city / neighborhood and who want to work together on specific problem solutions. It provides step-by-step instructions for setting up so-called living labs as low-threshold places for collaboration, learning and finding solutions together. In addition, there is an introduction to the concept of the Smart City as well as exercises and links to practical examples. The approach chosen here is based on the principles of Design Thinking, a successful method that was already tested as part of the ERSAMUS + SMACC project. • After this lesson the beneficiaries will be able to: • explain the need for sustainable urban development, • explain the idea of smart cities and “smart” neighborhoods • define a living lab and apply simple methods and tools to develop a living lab,

	• Apply the "Design Thinking" approach. • Define the most important fields of work and boundaries for your Living Lab • focus the content of your Living Lab on important topics, • identify the most important actors and stakeholders, • Develop an action plan for your Living Lab.

5.2. ECOWAS / Pan African Level

- **North African Countries**

5.2.1. Morocco

To reduce its energy bill, Morocco has adopted a national energy efficiency strategy that aims to achieve energy savings with a target set of around 20% by 2030 through better use of energy in all economic and social activity sectors [195].

Buildings are one of the major energy consuming sectors in Morocco, they represent 33% of final energy consumption and record important growth in annual energy consumption. The implementation of energy efficiency and renewable energy techniques in the construction sector is among the levers that will transform our energy future to meet the climate challenge in order to the kingdom objectives in the fight against climate change.

For all those reasons, several degrees and vocational training programs have been developed to build capacity around EE in buildings. Below are listed some of these programs.

5.2.1.1. Energy Efficiency in Buildings Trainings

42. Moroccan Agency for Energy Efficiency AMEE [196]	
Institution status	Public
Course title	Several modules on energy efficiency in building
Type of Training/Course	Vocational
Duration	5 days
Beneficiaries	Professionals, engineers, architects
Obtained Diploma/Certificate	Certificate
Description	The list of offered training programs is: • Energy efficiency in buildings - Thermal Regulation of Construction in Morocco • Control of the energy performance of buildings—BINAYATE software— • Solar thermal integrated into the building - Case of individual solar water heater installations • Solar thermal integrated into the building - Case of collective solar water heating installations • Photovoltaic solar energy integrated into the building - Case of interconnection to the electricity grid

	• Photovoltaic solar energy integrated into the building - Case of decentralized electrification • Energy audit in the tertiary sector - ISO 50002

43. IFMEREE [197]	
Institution status	Public
Course title	Associate degree (bac+2) in energy efficiency
Type of Training/Course	Academic
Duration	2 years
Beneficiaries	High school degree holders
Obtained Diploma/Certificate	Technician degree
Description	**The programme is intended to train qualified technicians who are able to:** • Participate in the planning and sizing of three components: EE in the building structure, EE in the building lighting, and EE in the building's electrical network • Monitoring of the completion of the work corresponding to the four components on a site • Participate in energy audits of buildings.

44. Mohammed 5 University [198]	
Institution status	Public
Course title	Energy Efficiency and Building acoustics
Type of Training/Course	Academic
Duration	1 year
Beneficiaries	Holders of a 2 years (the general university studies diploma DEUG/BTS/DUT) university degree after high school in construction and building energy—energy—Civil engineering…
Obtained Diploma/Certificate	Professional 3-year Bachelor
Description	This training will allow beneficiaries to acquire skills for better professional integration in the various fields related to energy efficiency and acoustics applied to buildings (photovoltaic installations—solar thermal installations - energy audit - energy management—l thermal and acoustic insulation…). **The trainings courses are as follows:** • Comfort—materials—performance • Thermal and acoustic of the envelope • Building acoustics and ventilation systems

	• Energy audit of the building envelope • Architectural acoustics • Building thermal and acoustic simulation tools • Energy management • Calculation of collective solar thermal installations • Calculation of photovoltaic installations connected to networks **At the end of this training—the beneficiaries—will be able to master:** • Energy audit techniques and energy management related to the building. • The procedures for correcting and soundproofing a building • Techniques related to the sizing and installation of energy systems.

5.2.1.2. Urban Planning Courses

45. Institut National d'Aménagement et d'Urbanisme (INAU) [199]	
Institution status	Public
Course title	Specialized Master in Urban Planning and Planning
Type of Training/Course	Academic
Duration	1 year
Beneficiaries	Professional Bachelor degree holders Bachelor degree holders Architects, Engineers
Obtained Diploma/Certificate	Specialized Master's degree
Description	**The new context of the making of the city and the territories is marked primarily by:** the rise in power of participatory urban planning and governance, the injunction to sustainable development, the reign of uncertainty and risk and finally the wide dissemination of urban practices and models throughout the world…etc. so many challenges that require support through an adequate training strategy in the areas of development and town planning. **The main missions behind this Master's degree are:** • The training of high-level professionals capable of setting up, negotiating and evaluating regional projects. In short, territorial managers endowed with a spirit of synthesis and a force for anticipation, as well as the training of researchers and territorial experts capable of carrying out in-depth reflection on the issues of regional planning and development.

	• Continuous training for the benefit of stakeholders, particularly in the new professions of intermediation, negotiation and social support. But also in the field of tools: GIS, survey techniques, communication and territorial marketing, etc. • Basic research, action research and expertise within CERAU on new issues including the evaluation of strategies and territorial foresight, CERAU also functions as a place of internships and training for doctoral students.

5.2.2. Tunisia

The sum of the energy consumption in Tunisia represents 27% of the final energy consumption, a percentage is expected to increase in the coming years. The building sector represents a high potential for energy savings that could reach 56% by 2030. The energy efficiency potential applied to all buildings in the public sector identified as an energy-intensive building, reached 39,667 tep, representing 21% of public sector consumption and 2.4% of tertiary sector consumption[64].

46. Action [200]	
Institution status	Private
Course title	Training modules on energy efficiency
Type of Training/Course	Vocational
Duration	3-day courses, 5-day courses and 15-day course
Beneficiaries	Professionals
Obtained Diploma/Certificate	Certificate
Description	The training contains a number of themes, and are represented as follows: • Energy bill and optimization of electrical energy. • Study, design and energy management of lighting. • Production, distribution and operation of compressed air. • Evaluation of the energy performance of compressed air production systems according to ISO 11011:2013 • Evaluation of the energy performance of pumps and electric motors according to ISO 14414:2015 • Production, distribution and energy management of industrial refrigeration • Energy auditor in the tertiary and industrial sectors • Energy performance measurement and verification protocol according to IPMVP

47. Mediterranean Polytechnic School EPM [201]	
Institution status	Private
Course title	Professional Master in Audit and Energy Efficiency
Type of Training/Course	Vocational
Duration	2 years
Beneficiaries	Bachelor's degree holders or equivalent
Obtained Diploma/Certificate	Professional Master
Description	The training of the Expert in audit and energy efficiency revolves around 4 areas of activity: • Identify, measure and evaluate the energy consumption of the building within the framework of the specificities and regulations in force • Design and propose technical solutions • Integrate and master economic, environmental and social approaches • Manage a portfolio of projects and associated teams. Each area of activity allows the development of the following skills: • Know the challenges of the energy transition; • Evaluate the thermal of a building and perform dynamic thermal calculations • Measure the humidity and the water vapor transition • Master existing RTs, THCE-ex and labels and certifications • Perform an energy audit • Perform an air quality audit • Master and identify renewable energies • Be proactive in lighting solutions • Perform the life cycle analysis of a building • Offer adequate heating, ventilation and air conditioning solutions • Control costs throughout the renovation process • Support the social dimension of projects • Supervise and manage a renovation project

5.2.3. Egypt

The Egyptian building sector requires approximately half of the total electric supply. Governmental buildings occupy 5% of the supply. As a result, the government of Egypt initiated some steps toward making this sector more energy efficient [202].

Egypt implemented a building code in 2005, but unfortunately this has not led a wide range of training infrastructure in bioclimatic and energy-efficient buildings. Most available programmes are provided by international universities, which are not necessarily adapted to Egypt's context. Below are examples of those programmes.

5.2.3.1. Energy Efficiency in Buildings Trainings

48. The American University in Cairo [203]	
Institution status	Private
Course title	Green Technologies Diploma (Pro-Green): Building specialization
Type of Training/Course	Vocational
Duration	12–18months
Beneficiaries	Professionals and individuals, with a Bachelor degree in natural science, mathematics, engineering or architecture, interested in and/or involved in the development and implementation of green technologies in their practice including architects, engineers, facility managers and contractors.
Obtained Diploma/Certificate	Certificate
Description	The objective of the green technologies professional online diploma is to promote a problem-based approach among professionals pursuing careers in green industries and green careers. This professional certification program is offered jointly by The American University in Cairo, the American University of Beirut and the Lebanese American University in three specializations including the building specialization. The building specialization has the following courses: • Sustainable Restoration of Existing Buildings • Low Energy Architecture and Passive Building Design • Sustainable Building Materials • Renewable Energy Systems and Energy Efficiency in Buildings • Moisture and Control of Humidity in Buildings • Green Building Basics and Building Rating Practices • Construction and Demolition Waste Management • Refrigeration and Heat Pumps • Building Energy Systems Modeling • Energy Management System of Buildings • Sustainable Building Design and Construction

49. British University in Egypt [204]	
Institution status	Private
Course title	Environmental Sustainable Architecture Engineering
Type of Training/Course	Academic
Duration	Preparatory Year + 4-year B.Sc (5 years)
Beneficiaries	Students with a high school diploma

Obtained Diploma/Certificate	A bachelor's degree of science
Description	The BUE aims through this program to achieve sustainable development principles and objectives in all areas. Providing graduates fulfilling the market's diversity of needs. **Among the modules students will study under this program:** • Eco design for zero energy and passive building • Air conditioning and heat pump engineering • Introduction to environmental and sustainable design • Sustainable construction technologies • Architecture surveying and drawing • Urban and landscape design • Environmental control systems • Air conditioning and heat pump engineering

50. International Academy for Renewable Energy and Energy Efficiency (IAREEE) [205]	
Institution status	Private
Course title	LEED Green Associate | Exam Preparation
Type of Training/Course	Vocational
Duration	2 days
Beneficiaries	Professionals
Obtained Diploma/Certificate	-
Description	LEED is an internationally recognized green building certification system, providing third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most: energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. Developed by the U.S. Green Building Council (USGBC), LEED provides building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.

5.2.4. Libya

Libya, a member of OPEC, possesses one of the world's largest unrefined petroleum reserves, and is an important natural gas and oil exporter to the world.

Total primary energy consumption and installed energy capacity in Libya is 100% based on fossil fuels. The energy building consumption is over 40% and it is mainly used in water heating.

The Libyan government is determined to diversify its energy mix by exploiting the country's solar and wind potential. By 2030, Libya aims for 22% of electricity generation to come from renewable energy. Libya is also in the process of implementing its NEEAP (National Energy Efficiency Action Plan).

REAOL (Renewable Energy Authority of Libya) has been given the responsibility of carrying out the work of Energy Efficiency to the stage of implementation:

- Coming up with the National Energy Efficiency Action Plan (NEEAP)
- Proposing the necessary laws, regulations, incentives and get it approved by the government
- Increasing people's awareness and public acceptance of the importance of energy conservation

Nevertheless, there are no specific data regarding energy efficiency training programs and courses offered in Libya due to the political situation, which prevents access to this information, particularly regarding the training infrastructure.

5.2.5. Algeria

In Algeria, buildings are one of the major energy consumers. Excluding hydrocarbons, it absorbs 42% of total final energy consumption, including 35% for residential and 7% for the tertiary sector. Transport is second (35%) and industry is third on this podium with 16%. Buildings are therefore one of the priority targets for action by the Algerian state in energy efficiency (EE).

APRUE is implementing the national energy efficiency program (PNEE) for the construction and building sectors. The PNEE targets four objectives: thermal insulation of housing, thermal rehabilitation, the installation of individual solar water heaters and the distribution of LED lamps for households and public lighting. Algeria aims to implement an energy label comparable to that affixed to household appliances [206].

With that in mind, the offer in terms of bioclimatic building training is still low.

5.2.5.1. Energy Efficiency in Buildings Trainings

51. University of Tlemcen [207]	
Institution status	Public
Course title	Civil engineering: Energy efficiency in construction buildings
Type of Training/Course	Academic
Duration	4 semesters
Beneficiaries	This Master is open to any candidate holding a license (bachelor's degree) in one of the following fields: ST (Civil Engineering Stream). ST, mechanical engineering, option: renewable energy and energy efficiency Architecture Another ST license related to the field
Obtained Diploma/Certificate	Professional Master's degree

Description	The brand-new professional master's degree in "Energy efficiency in construction buildings" was launched in 2018 at Abou Bekr Belkaid University in Tlemcen. A first in Algeria. The project includes 03 universities from the north of the Mediterranean (Genoa, La Rochelle, Warsaw) and 03 universities (+ 03 other affiliates) from the south of the Mediterranean (Tlemcen, Mostaganem, Fès, Marrakech, Sousse and Gabes), in addition to the partners of the socio-economic sector on both sides. The proposed project introduces innovative tools and methodologies of modernization and internationalization in Algeria, Morocco and Tunisia, mainly concerning the use of new environmental returns to improve the availability of academic resources to support teachers and students in the process of capacity building and the development of a new inter-university master's degree. the profile of engineers in energy efficiency and energy management in buildings allows graduates to: Carry out energy audits and diagnostics. Offer energy efficient solutions. Design, initiate, sell, implement, manage and monitor installations using renewable energies. Creation of micro-enterprises in energy efficiency.

West African Countries

The West Africa region is characterized by a low rate of access to modern energy services, penalizing the growth possibilities of West African countries. This region is generally characterized by a very low rate of access to modern energy services, which obstructs possibilities for the development of economic activities, the provision of basic social services and the fight against poverty. The Regional Center for Renewable Energies and Energy Efficiency (CEREEC) of ECOWAS was founded to create a favourable and conducive framework for renewable energy and energy efficiency markets in order to support activities aimed at reducing the obstacles to the development of these sectors. Capacity building is therefore called to play a crucial role in the vision of ECREEE. Without capacity building, it is impossible to implement programs and investment projects in the field of renewable energies (RE) and energy efficiency (EE).

5.2.6. Ghana

Most training sessions on bioclimatic buildings in Ghana took place in the framework of internationally funded projects, and/or are not regularly offered. For instance, Solid Green Consulting, a South African consulting company, organized three-day training workshops in October 2019 on green buildings for the Ghana Green Building Council and professionals. The purpose of the workshops was to set out the different methods of compliance for future buildings to acquire their local authority approvals [208]. Another research and development project by the African Development Bank (AfDB) consisting of performing energy audits in public and commercial buildings commissioned the international consulting firm Econoler to disseminate through its expert training sessions on the above-mentioned topics [209].

5.2.6.1. Energy efficiency in buildings training

52. Institute for Sustainable Energy and Environmental Solutions ISEES [210]	
Institution status	Non-profit institution
Course title	Renewable energy and energy efficiency
Type of Training/Course	Vocational
Duration	-
Beneficiaries	Youth, women and professionals
Obtained Diploma/Certificate	Certificate
Description	Established in 2014, ISEES is a non-profit development organization that provides professional technical training, research, consultancy, community development and technology deployment in the areas of renewable energy and energy efficiency, climate change, environmental conservation, natural resources management, water, sanitation and hygiene aimed at improving the livelihoods and environment of households, communities and small enterprises in Ghana and Africa. ISEES promotes energy conservation education, advisory as well as technology promotion in households and businesses in Ghana and Africa. ISEES trains young energy efficient entrepreneurs to go into the business of energy efficiency including sales of LED Bulbs and other efficient appliances as well as joins committees in improving sectors.

5.2.7. Senegal

Senegal was one of the beneficiary countries of the Programme for Energy Efficiency in Buildings (PEEB). One of the outcomes of this project is an online training on financing energy efficiency in buildings. The course covered the following topics:

- Understanding of the economic and environmental dimensions of energy
- Efficiency in buildings, from the local to the international level
- Technical requirements for design and operation
- Financial methods and evaluation criteria for energy-efficient projects
- Financing options, business plans, and risk assessments

45 Senegalese professional from the building sector attended the lectures, and more are expected to benefit from the online training, which its continuity is currently under discussion [211].

5.2.7.1. Urban Planning Courses

53. African Institute of Urban Management (IAGU) and Senghor International University [212]	
Institution status	Partnership between public and private
Course title	Urban Planning Urban Planning and Environment

Type of Training/Course	Academic
Duration	2 years
Beneficiaries	Bachelor degree holders
Obtained Diploma/Certificate	Master's degree
Description	The master program covers topics including sustainable urban planning and environmental urban management.

54. Graduate School of Applied Economics (ESEA) [213]	
Institution status	Public
Course title	• Planning engineering • Land use planning engineering • Urban development engineering • Planning, decentralization and territorial development
Type of Training/Course	Academic
Duration	5 years
Beneficiaries	High school degree holders
Obtained Diploma/Certificate	Engineering degree
Description	-

5.2.8. Nigeria

In Nigeria, energy consumed by medium-high cost residential and commercial buildings is mainly due to cooling systems (e.g., air conditioning) and lighting. Energy consumed by residential buildings accounts for more than 50% of the total energy consumed in the country [214].

Uneconomical and inefficient electrical appliances (lighting, refrigeration, air conditioning, motors, fans, etc.), are used which unbalance the demand-supply consumption.

By using bioclimatic design techniques with highly efficient active systems, it would be possible to significantly reduce the energy required to cool and light a building, or even in some cases eliminate the need for cooling entirely. This in turn would reduce the dependency on the grid electricity supply and help improve energy security.

The country experiences a lack of legal framework and regulation in addition to a lack of awareness on energy efficiency in order to address the situation. Inadequate trained personnel and professionals are another factor inhibiting the development of energy efficiency. Until 2016, training on energy efficiency barely existed - with a limited availability of EE technical information and training. The Nigerian Energy Support Program (NESP) addressed this challenge by introducing relevant qualifications into Nigeria.

Therefore, seven clean energy qualifications were introduced in 2016 in order to enhance employment prospects of trainees on the following topics:

- Solar PV Installation
- Solar PV Installation Supervision

- Mini-Grid Design
- Rural Hydropower Civil Engineering
- Energy Management
- Energy Audit
- Energy Efficient Building Design.

5.2.8.1. ENERGY EFFICIENCY IN BUILDINGS COURSES

55. Renewable energy technology training institute (RETTI) [215]	
Institution status	Private
Course title	Energy Efficiency and Management in Buildings
Type of Training/Course	Vocational
Duration	1 week
Beneficiaries	Individuals intending to improve the energy efficiency of a building. Architects, engineers and building engineers. Individuals considering a consultancy job in the energy-saving field.
Obtained Diploma/Certificate	Certificate
Description	The course intends to: • Create energy and financial savings by reducing energy consumption • Reduce CO2 emissions produced by a building • Assess the current energy consumption and create an action plan on how to reduce consumption.

5.2.9. Togo

In Togo, the concern of renewable energies arises as in other countries of the African sub-region, particularly in the West African Economic and Monetary Union (UEMOA) area. This has led the UEMOA states to federate their efforts to come out with a common bill to address the issues of global warming and to mitigate the negative impact due to the use of fossil fuels and thus improve Togo´s carbon print.

Among the actions carried out in Togo, there are the sensitization of the populations and the provision of domestic solar kits within the framework of the project called CIZO (energy or light in the local language). Added to this is the training of executives and professionals who shape cities.

Among the educational institutions that host these training courses, the following can be mentioned:

56. Ecole Africaine des Métiers de l'Architecture et de l'Uranisme (EAMAU) et Institut de la Francophonie pour le Développement Durable (IFDD) [49]	
Institution status	Public

Course title	Building the capacities of decision-makers and professionals in the urban planning, construction and building sector to implement the new urban agenda
Type of Training/Course	Seminar and conferences
Duration	6 months
Beneficiaries	Professionals and actors of Urban Development for the improvement of their capacity in terms of sustainable development and renewable energies.
Obtained Diploma/Certificate	Certificate
Description	The training takes place in two classroom-based sessions which complement each other and / or draw on concepts addressed in other themes to remain in the logistics of the systemic: be complementary and give a holistic vision of a subject treated from different viewpoints. The main themes retained are treated according to 3 educational axes "understanding", "Identifying and appropriating the tools" and "Strengthening the capacity to act" **and are divided into modules and technical visit as follows:** • **Module 1:** Climate, Energy and energy transition • **Module 2:** Issues and challenges of territories facing the energy transition • **Module 3:** Renewable energies (RE) and Energy efficiency (EE) • **Module 4:** Construction and building / Traditional materials and local resources • **Module 5:** Transport and mobility and city management • Technical visit

57. Ecole Africaine des Métiers de l'Architecture et de l'Urbanisme (EAMAU) [50]	
Institution status	Public
Course title	Master 2 in Transport and Sustainable Mobility in African Cities
Type of Training/Course	Academic
Duration	1 year
Beneficiaries	Bachelor's degree holders / Master's degree
Obtained Diploma/Certificate	Master 2 degree
Description	**The training provides students with the keys and working methods to:** • Analyze, understand and respond to the demand for mobility in African cities

	• Develop, optimize and operate multimodal transport networks • Develop and implement urban mobility policies and urban travel plans in African cities • Adapt to specific situations in the African context. **The general structure of the training is as follows:** • **UE1:** Urban dynamics and mobility challenges in Africa • **UE2:** Mobility request • **UE3:** Planning of urban and regional mobility • **UE4:** Governance and planning of urban mobility • **UE5:** Integrated transport offer • **UE6:** Roads, traffic and road safety management • **UE7:** Operation and management of multimodal transport networks • **EU 8:** Environment, transport and innovation • **Unit 9:** Methodology for writing and defending the thesis • **UE 10:** Writing of the dissertation • **UE: 11:** Thesis defence

58. Ecole Africaine des Métiers de l'Architecture et de l'Uranisme (EAMAU) [51]	
Institution status	Public
Course title	Architecture and Heritage, Urban planning and development, Urban and Environmental Management
Type of Training/Course	Academic
Duration	5 years
Beneficiaries	High school degree holders
Obtained Diploma/Certificate	Master's degree
Description	The courses in these different sectors have in common the courses on sustainable development and issues related to energy sobriety. At the end of their training, graduates are able to take into account the issues of sustainable development in their urban and architectural design project, as well as in the management of the living environment in the context of sub-Saharan African cities and beyond.

59. Université de Lomé (UL) [52]	
Institution status	Public
Course title	Master in Sustainable Cities in Africa

Type of Training/Course	Academic
Duration	2 years
Beneficiaries	Bachelor degree holders
Obtained Diploma/Certificate	Master's degree
Description	The Master "Sustainable Cities in Africa" mainly aims to train students in basic and applied research in the design, implementation and effective management of sustainable urban development projects in Africa. **Specifically, students from this training will be able to:** • Use the techniques and tools necessary for research, for the analysis of spaces and for the development of urban projects; • Understand the challenges of urban development in order to produce strategic and operational planning tools at the scale of cities and metropolitan areas; • Design projects and strategies to reduce difficulties in accessing basic equipment and services; • Develop projects integrating HQE (High Environmental Quality) construction techniques and processes; • Evaluate the environmental and social impact of human activities in urban areas; • Identify the territorial, economic, technological and architectural challenges for the management and upgrading of spaces; • Develop strategies and methods for the prevention of natural disasters (floods, submersions, coastal erosion), industrial risks and pollution, etc .;

60. Université de Lomé (UL) [53]	
Institution status	Public
Course title	Doctorate in Sustainable Urban Development
Type of Training/Course	Academic
Duration	4 years
Beneficiaries	Master's degree holders
Obtained Diploma/Certificate	PhD's degree
Description	The Doctoral Research Program in Sustainable Urban Development mainly aims to develop a wide field of expertise on sustainable cities in Africa; to upgrade skills in sustainable urban development and to train experts in sustainable urban development capable of meeting the current and future needs of African cities. At the end of the training, the knowledge and skills acquired should allow CERViDA - DOUNEDON students to be able to:

	• Innovate through research, effective and efficient practices in sustainable urban development • Understand the challenges of sustainable urban development in order to produce strategic and operational planning tools at the scale of cities and metropolitan areas; • Develop programs / projects / strategies for sustainable urban development.

5.3. Overview of trainings in the EU, North and West Africa regions

The following two tables give an overview on the trainings described in the previous chapters.

Table 2: Overview of trainings on EE in buildings in the EU, North and West Africa regions

Region & Country	Institution		Title	Type		Duration	Beneficiaries	Diploma		
	Private	Public		Professional	Academic			Certificate	Bachelor	Master
EU - GER	x		Energy and energy efficiency, climate protection, subsidies for the energy consultancy industry	x		Several months, part-time	Professionals	x		
EU - GER	x		Applying Energy Efficiency	x		6 months, part-time	Professionals	x		
EU - GER		x	Building Sustainability – Management Methods for Energy Efficiency		x	4 semesters, full-time	Bachelor students			x
EU - GER		x	Green Building Design		x	6 semesters, full-time	Students with entrance qualification		x	
EU - GER		x	Building Services and Energy Technology		x	6 semesters	Students with a technical college entrance qualification		x	
EU – SP		x	Environmental Design and Management of Buildings		x	1 year	Recent graduate or graduate in Architecture, Engineering or other equivalent qualification			x
EU – SP	x		Passive House Tradesperson			32 hours	Active and unemployed workers in the construction sector	x		
EU - SP	x		Energy Efficiency in Buildings			920 hours	Unemployed	x		
EU - SP	x		Energy Efficiency Course in Building and Industry			16 hours	Architects, Industrial Engineers, Technical Engineers and professionals in general, interested in Energy Efficiency and in the application of corrective measures and improvement of energy efficiency.	x		

EU - PR		x	CBTE Module - Basic Concepts of Thermal in Buildings			4 hours	All trainees wishing to undergo training on energy performance legislation for buildings	x		
EU - PR		x	Energy Rehabilitation and Building Conservation		x	2 years	Holders of secondary education (regular or professional); Technicians			
EU - PR	x		Sustainability and Energy Management for Buildings	-	-	-	Graduate degree holders	x		
EU - PR		x	Specialization Course in Energy for Sustainability	x	x	2 semesters	Holders of a degree in the area of Economics, Management, Engineering, Natural sciences, or Architecture	x		
EU - IT		x	Engineering for Building Retrofitting		x	2 years	Bachelor's degree holders in one of the following fields: Civil Engineering, Environmental Engineering, Building Engineering, Architecture, Industrial Engineering.			x
EU- FR		x	Civil engineering Course: High energy efficiency building	x	x	4 semesters	1st Year Master's degree students and Engineering school students			x
EU- FR		x	Civil engineering building engineering course: management and integration of energy efficiency and renewable energies "IB-GI3ER"		x	4 semesters	Students with Bachelor's degree (3 or 4 years) or equivalent with knowledge of civil engineering			x
EU- FR		x	Energy Efficiency in Building Renovation		x	1 year	The beneficiary must hold one of the following levels of diplomas and/or experience: An engineer title (generalist or specialist); An architectural diploma; A technical or scientific Master 2; A technical or scientific Master 1 coupled with 3 years of professional experience in the building industry.			x
EU- FR	x		Expert in Economics and Energy Efficiency of Buildings	x		41 days	The beneficiary must master the basics of building thermics	x		
EU-AT		x	Urban Renewable Energy Technologies		x	6 semesters	Technicians & Engineers		x	
EU-AT		x	Building Innovation	x	x	5 Semester	Building physicists, Technical planners TGA or MSR, Civil engineers, Architects, Civil engineers, Property developers,	x		x

							Executors in the construction industry, Builders, Facility managers, Teachers of relevant subjects and Those interested in future-proof building planning			
EU-AT		x	Integrated Facility and Energy Management	x	x	4 semester/ 2 semesters	Experts in construction engineering, building services or electrical engineering. The program is for people who need to develop their management skills alongside their technical expertise, due to changes in legal requirements and technical innovations.			x
EU-AT		x	Smart Building: Energy Efficient Building Technology & Sustainable Construction		x	6 semesters	Engineers & Technicians		x	
EU-AT	x	x	Building renovation/ Building materials and facade systems		x	Self-Paced	Anyone interested in the courses offered for free			
EU-AT	x	x	Energy-efficient building concepts		x	Self-Paced	Anyone interested in the courses offered for free			
EU-AT		x	Building technology and building automation		x	6 semesters	Specialists who are involved in the planning, installation or on-going operation of technical facilities in buildings		x	
EU-AT		x	Building technology and building management	x	x	4 semesters of technical studies	Building technicians and building managers			x
EU-AT			Basics of Energy consulting (A-course)	x			Employees of planning and executing companies in the field of construction and building services People who work or want to be active in the construction sector in an advisory capacity. Community workers	x		
EU-AT			Energy consultant (F-course)	x			Employees of planning and executing companies in the field of construction and building	x		

							technology with relevant professional training as well as everyone who has completed the A course and wants to qualify for a job as an energy consultant. Engineers, Technicians and consultants			
EU-AT			Energy consultant training (A course)	x			Employees of planning companies, technical offices, authorities or municipal administrations. Employees in the main construction or ancillary construction trades, consultants in specialist stores, Customer advisors from energy supply or energy service companies, Members of e5 teams, people who work or want to be active in the construction sector in an advisory capacity.	x		
EU-AT	x		Smart Building Technologies		x	6 semesters	Students with: A university entrance qualification (e.g. Matura, relevant university entrance qualification, vocational qualification). Without a university entrance qualification but with relevant professional qualification (Engineers, Technicians…), provided that one of the following prerequisites is also met: - successful completion of a relevant, vocational secondary school or Successful completion of a dual training program in relevant apprenticeships.		x	

NA-MRC		x	Several modules on energy efficiency in building			5 days	Professionals, engineers, architects	x		
NA-MRC		x	Associate degree (bac+2) in energy efficiency		x	2 years	High school degree holders			
NA-MRC		x	Energy Efficiency and Building acoustics		x	1 year	Holders of a 2 years (the general university studies diploma DEUG/BTS/DUT) university degree after high school in construction and building energy—energy—Civil engineering…		x	
NA-TN	x		Training modules on energy efficiency			3-day courses, 5-day courses and 15-day course	Professionals	x		
NA-TN	x		Audit and Energy Efficiency	x		2 years	Bachelor's degree holders or equivalent			x
NA-EGY	x		Green Technologies Diploma (Pro-Green): Building specialization			12–18months	Professionals and individuals, with a Bachelor degree in natural science, mathematics, engineering or architecture, interested in and/or involved in the development and implementation of green technologies in their practice including architects, engineers, facility managers and contractors.	x		
NA-EGY	x		Environmental Sustainable Architecture Engineering		x	Preparatory Year + 4-year B.Sc (5 years)	Students with a high school diploma		x	
NA-EGY	x		LEED Green Associate | Exam Preparation			2 days	Professionals			
NA-ALG		x	Civil engineering: Energy efficiency in construction buildings		x	4 semesters	This Master is open to any candidate holding a license (bachelor's degree) in one of the following fields: ST (Civil Engineering Stream). ST, mechanical engineering, option: renewable energy and energy efficiency Architecture Another ST license related to the field		x	

WA-Ghana			Renewable energy and energy efficiency			-	Youth, women and professionals	x		
WA-Nigeria	x		Energy Efficiency and Management in Buildings			1 week	Individuals intending to improve the energy efficiency of a building. Architects, engineers and building engineers. Individuals considering a consultancy job in the energy-saving field.	x		

Table 3: Overview of trainings on urban planning with topics relevant for bioclimatic buildings in the EU, North and West Africa regions

Region & Country	Institution		Title	Type		Duration	Beneficiaries	Diploma		
	Private	Public		Professional	Academic			Certificate	Bachelor	Master
EU - GER		x	Sustainable Urban Development		x	2 years/4 Semesters	Students holding a Bachelor of Science degree or Bachelor of Engineering degree in a similar or an equivalent degree (additional requirements might apply on the potential beneficiaries)			x
EU - GER		x	Transformation of Urban Landscapes TUL		x	2 years/4 semesters	Students with a B.A/Sc. degree in Geography, Spatial Planning ("Raumplanung") or similar equivalent study programmes from Germany or other countries and thorough knowledge of English.			x
EU-SPA	x		City Resilience Design and Management		x	1 year	This program is intended for city practitioners and consultants with at least 2 years of work experience in fields related to sustainability and resilience, as well as university graduates (Graduate Degree or Bachelor's Degree) from the following fields: Planning, Management, Urban Design, Engineering, Environmental, and Social Sciences, Political Science, Geography and Architecture.			x
EU-PO		x	Sustainable Urbanism and Spatial Planning		x	2 years	Holders of a 1st cycle, bachelor's degree or master			x
EU-IT		x	Territorial, Urban, Environmental and Landscape Planning		x	2 years	Holder of Bachelor's degree			x

EU-FR		x	Urban Planning and Development: Specialization in -Housing, city policy and urban renewal Landscape and landscaping specialty Specialization in sustainable urban planning, project and operational action		x	2 years or over	Students with a Bachelor's degree			x
EU-FR		x	Sustainable urbanism and development		x	2 years	Professionals, urban planners and developers			x
EU-FR		x	Sustainable Development and Urbanism, Environment" (AUDE) Sustainable Planning and Urbanism, Environment (AUDE): Urbanism and Development Specialization; Environment and Planning Specialty		x	1 year for both degrees	The beneficiary must have a level of study of 2 years after high school Diploma		x	x
EU-AT		x	Renewable Urban Energy Systems	x	x	4 semesters- part time	Technicians & Engineers			x
EU-AT		x	Smart Buildings in Smart Cities- Energy Infrastructure and District Renovation		x	4 semesters/part time	Students and anyone with the following qualifications: A relevant university degree (bachelor's or master's degree in technology) or an equivalent degree from a post-secondary educational institution Mastery of the German language (level B2), good knowledge of English (teaching partly in English)			x
EU-AT	x	x	Urban development	-	-	Self-Paced	People who want to change something in their city / neighborhood and who want to work together on specific problem solutions.			
NA-MO		x	Urban Planning and Planning		x	1 year	Professional Bachelor degree holders Bachelor degree holders Architects, Engineers			x
WA-SEN			-Urban Planning -Urban Planning and Environment		x	2 years	Bachelor degree holders			x

WA-SEN		x	-Planning engineering -Land use planning engineering -Urban development engineering - Planning, decentralization and territorial development		x	5 years	High school degree holders			
WA-Togo		x	Building the capacities of decision-makers and professionals in the urban planning, construction and building sector to implement the new urban agenda			6 months	Professionals and actors of Urban Development for the improvement of their capacity in terms of sustainable development and renewable energies.	x		
WA-Togo		x	M2: Transport and Sustainable Mobility in African Cities		x	1 year	Bachelor's degree holders / Master's degree 1st year			x
WA-Togo		x	Architecture and Heritage, Urban planning and development, Urban and Environmental Management		x	5 years	High school degree holders			x
WA-Togo		x	Sustainable Cities in Africa		x	2 years	Bachelor degree holders			x
WA-Togo		x	Doctorate in Sustainable Urban Development		x	4 years	Master's degree holders			

6. Analysis

From the prior section of this paper it can be concluded that there exists a large gap between the three regions regarding the training infrastructure of energy efficiency in buildings, but also within the different African countries. Compared to the EU, North and West African countries lack training programs for bioclimatic architecture. This coincides with the lack of regulatory infrastructure for energy efficiency in buildings, as showcased in the first chapter of this report.

This study compiled examples of different types of training programs on EE in buildings in various countries. These examples have common characteristics but also significant differences in terms of structures and objectives. This diversity is partly due to the differences in the educational traditions of the countries, but also to the political and market value of the approaches: countries do not place the same importance on different aspects of EE in buildings. For example, European countries place more emphasis on heating technologies than African countries, which is consistent with the geographical and climatic conditions of the regions.

These differences in approach also have consequences for the design of vocational or continuing training programs: geographic and educational differences between countries do not allow the creation of common regulations to guide the developers of the training programs. The main difference, however, that was observed between the regions and countries is the lack of certification of professionals in the different themes which pertain to EE in buildings.

Relevant actors and organizations in the North and West Africa region do not need to be accredited or certified immediately, but mechanisms should be in place from the start to facilitate the eventual transition to accreditation or certification at a later stage, hence the need to build training programs based on international existing codes as opposed to national current needs. Until then, the term “accreditation” can be used to mean compliance with standards set by an accreditation body.

The process leading to the definition, adoption, implementation and application of quality standards and quality assurance mechanisms for trainings on EE (and RE) should follow a sequential approach and focus on the following topics, in the order listed:

- The professions or professional activities in the field of EE in buildings with the greatest training needs are identified.
- As soon as the first analysis is completed, training programs are developed to meet the needs of all target groups, from people without experience up to those who already obtained a university degree. It is essential that the developed programs include a significant part of practical training.
- In addition, there is a need to identify existing trainers and training providers capable of delivering trainings on EE (and RE). Training of trainers is provided to prepare trainers for new training requirements (both technical and didactic).
- Governments should use their power to introduce a mandatory certification system for companies working in the sector of EE in buildings, especially where facilities are co-financed with public funds.
- The company certification system must cover all the professions concerned (installers, technicians and engineers).

- The system must be introduced gradually: the requirements must be defined at a minimum level so as not to overload the industry; and only technologies and professional activities showing the most pressing training needs should be included at the outset. It will then be possible to gradually increase the requirements.
- The compulsory certification phase should not remain in effect indefinitely. The certification requirement is removed once a large and mature market has been established. The system certification can then be transformed into a market instrument.
- Adhering to international norms and standards can be costly and time consuming to normalise for the host country, yet it is not necessary for such a certification system to be immediately accredited under international standards. However the quality management and assurance mechanisms for quality should be implemented as soon as possible to facilitate the eventual transition to accreditation at a later stage.

7. Training Infrastructure Conclusion

The research conducted in this paper has pointed out that there are similar training modules in energy efficiency as well as passive and bioclimatic buildings. Nevertheless, modules in urban planning were largely non-existent apart of academic degrees related to architecture or urbanism.

It seems preferable that the process for improving the quality of training facilities on EE in buildings in each country proceeds in phases. The preparation phase is important and should concern the development of professional standards and training programs.

To gain time and resources, it is recommended that the analysis and training programs be developed first, based on codes of practice at international level as opposed to existing codes as the benchmark has demonstrated. The training programs can then be adapted to national requirements once these have been determined. In general, the analysis from research and interviews for this study concludes the following:

- The main barriers to capacity building in the bioclimatic building sector are the quality and relevance of training, regulation in countries and lack of funding.
- The majority of offered programmes in North and West Africa focus on the application of RE in buildings.
- The organization of periodic training for actors in the building sector is considered essential for effective capacity building

Additionally, there are other obstacles

- The regulations and policies in place in the regions concerned do not favour the rapid development of EE projects
- Good public-private partnership and energy subsidies for the poor can improve access to energy services in Africa.

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Annex A – Regulation Questionnaire

INFORMATION ON THE INSTITUTION

Name	
Address	
Country / region	
Phone	
E-mail	

INFORMATION ON THE CONTACT PERSON

Name	
Position	
Phone	
E-mail	

REGULATORY INFRASTRUCTURE QUESTIONNAIRE

Do you have in your country laws, regulations, standards, labels, or certificates on energy efficiency in buildings?

☐ Yes

☐ No

Do you have in your country laws, regulations, standards, labels, or certificates on passive or bioclimatic approaches in buildings?

☐ Yes

☐ No

Do you have comfort standards in your country?

☐ Yes

☐ No

For each law, regulation, standard, label or certificate please fill in the following form:

DATA COLLECTION FORM

EXISTING LAW, REGULATION, STANDARD, LABEL, CERTIFICATION

FORM N° /

1- TITLE

2- TYPE

☐ Law ☐ Regulation ☐ Standard ☐ Label ☐ Certification

Other (specify)

3- AGE OF BUILDING

☐ Existing construction

☐ Renovated construction

☐ New construction

4- TYPE OF BUILDING

☐ Residential

☐ Tertiary

☐ Hotel ☐ Health ☐ Education ☐ Administration ☐ Public building

Other (specify)

5- WHAT PART OF THE BUILDING IS SUBJECT TO THE ABOVE-MENTIONED LAW, REGULATION, STANDARD, LABEL, CERTIFICATION (E.G.: ENVELOPE [WALL, WINDOW, ROOF, ETC] OR EQUIPMENT [LAMP, HVAC SYSTEM, ETC])

6- WHAT APPROACHES ARE USED?

☐ Prescriptive approach (*heat transfer coefficient of each part of the building)*

☐ Performance approach (*the maximum limits of thermal requirements [kWh/m².year]*)

7- WHAT ARE THE SETPOINT TEMPERATURES

Summer ☐ Winter ☐

8- WHICH THERMAL COMFORT MODEL IS USED TO DEFINE COMFORT OBJECTIVES?

PMV model ☐ Adaptive model ☐

No thermal comfort model is used ☐

9- ARE THERE PRESCRIBED COMFORT CATEGORIES? HOW ARE COMFORT CATEGORIES DEFINED?

10- WHAT INTERNATIONAL STANDARDS ARE TAKEN INTO CONSIDERATION FOR THIS LAW, REGULATION, STANDARD, LABEL OR CERTIFICATE?

11- IS THE NOMENCLATURE OF THE ISO 52 000 STANDARD TAKEN INTO ACCOUNT?

☐ Yes ☐ No

12- WHAT ARE THE CONSTRAINTS AND OBSTACLES TO APPLYING THESE LAWS, REGULATIONS, STANDARDS, LABELS AND CERTIFICATES?

☐ Financial obstacle:

☐ Institutional obstacle

☐ Legal obstacle

☐ Technical obstacle

☐ Other

Please, join a copy of each law, regulation, standard, label, and certificate.

13- WHAT ARE THE EXISTING URBANIZATION PLANS IN YOUR COUNTRY / REGION?

14- DO URBANIZATION PLANS TAKE INTO ACCOUNT THE ENERGY EFFICIENCY ASPECT IN THE PASSIVE AND BIOCLIMATIC BUILDINGS?

☐ Yes
☐ No

If yes, describe how

15- WHAT IS THE PERCENTAGE OF FORMAL (USE OF AUTHORIZATIONS) AND INFORMAL CONSTRUCTION IN YOUR COUNTRY?

Formal construction	
Informal construction	

16-DO YOU PLAN TO CREATE A NEW LAW, REGULATION, STANDARD, LABEL OR CERTIFICATE?

Energy efficiency in buildings: ☐ Yes ☐ No

Passive and bioclimatic buildings: ☐ Yes ☐ No

Urban planning: ☐ Yes ☐ No

If yes, please fill out the following form:

DATA COLLECTION FORM

PLANNED LAW, REGULATION, STANDARD, LABEL, CERTIFICA /

FORM N°

1- TITLE

2- TYPE

☐ Law ☐ Regulation ☐ Standard ☐ Label ☐ Certification

Other (specify)

3- AGE OF BUILDING

☐ Existing construction

☐ Renovated construction

☐ New construction

4- TYPE OF BUILDING

☐ Residential

☐ Tertiary

☐ Hotel ☐ Health ☐ Education ☐ Administration ☐ Public building

Other (specify)

5- WHAT PART OF THE BUILDING IS SUBJECT TO THE ABOVE-MENTIONED LAW, REGULATION, STANDARD, LABEL, CERTIFICATION (E.G.: ENVELOPE [WALL, WINDOW, ROOF, ETC] OR EQUIPMENT [LAMP, HVAC SYSTEM, ETC])

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6- WHAT APPROACHES ARE USED?

☐ Prescriptive approach (*heat transfer coefficient of each part of the building)*

☐ Performance approach (*the maximum limits of thermal requirements [kWh/m².year]*)

7- WHAT ARE THE SETPOINT TEMPERATURES

Summer ☐ Winter ☐

8- WHAT INTERNATIONAL STANDARDS ARE TAKEN INTO CONSIDERATION FOR THIS LAW, REGULATION, STANDARD, LABEL OR CERTIFICATE?

9- IS THE NOMENCLATURE OF THE ISO 52 000 STANDARD TAKEN INTO ACCOUNT?

☐ Yes ☐ No

THANK YOU FOR YOUR PARTICIPATION!

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Annex b – Training Questionnaire

INFORMATION ON THE INSTITUTION

Name	
Address	
Country / region	
Phone	
E-mail	

INFORMATION ON THE CONTACT PERSON

Name	
Position	
Phone	
E-mail	

TRAINING INFRASTRUCTURE QUESTIONNAIRE

Do you have training / courses on energy efficiency in buildings?

☐ Yes ☐ No

If yes, how many?

Do you have training / courses on passive and bioclimatic buildings?

☐ Yes ☐ No

If yes, how many?

Do you have training / courses on urban planning?

☐ Yes ☐ No

If yes, how many?

For each training / course, please fill out the following form:

DATA COLLECTION FORM
EXISTING TRAINING / COURSE
FORM N° /

17-SUBJECT OF THE TRAINING/COURSE:

☐ Energy efficiency in buildings
☐ Passive and bioclimatic buildings
☐ Urban planning

18-TITLE

19-TYPE OF THE TRAINING / COURSE

☐ Academic training / course ☐ Professional training / course

Other (specify)

20-DURATION

21-THE OBTAINED DIPLOMA / CERTIFICATE

22-THE BENEFICIARIES:

☐ Managers ☐ Engineers ☐ Architects ☐ Technicians
☐ Craftsmen and construction workers

Other (specify)

Mixed (e.g. engineers, managers togeth *(specify)*

23-THE PROGRAM OF THE TRAINING / COURSE AND CONTENT:

Please join to this form the program and the content of each training / course and send it by e-mail.

24-WHAT ARE THE OBSTACLES TO PROVIDING THIS TRAINING / COURSE?

(specify)

REGION?

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9-1- Energy efficiency in buildings

☐ Managers ☐ Engineers ☐ Architects ☐ Technicians ☐ Craftsmen and construction workers ☐ Bank workers ☐ Insurance agencies

Other (specify)

9-2- Passive and bioclimatic buildings

☐ Managers ☐ Engineers ☐ Architects ☐ Technicians ☐ Craftsmen and construction workers ☐ Bank workers ☐ Insurance agencies

Other (specify)

9-3- Urban planning:

☐ Managers ☐ Engineers ☐ Architects ☐ Technicians ☐ Craftsmen and construction workers ☐ Bank workers ☐ Insurance agencies

Other (specify)

26-ARE THERE PROJECTS / AWARENESS ACTIONS ON ENERGY EFFICIENCY IN BUILDINGS, PASSIVE AND BIOCLIMATIC BUILDINGS AND URBAN PLANNING IN YOUR REGION?

☐ Yes ☐ No

If yes, which kind of projects / awareness actions?

27-WHO ARE THE BENEFICIARIES OF THESE PROJECTS / AWARENESS ACTIONS?

☐ Managers ☐ Engineers ☐ Architects ☐ Technicians ☐ Craftsmen and construction workers ☐ Bank workers ☐ Insurance agencies ☐ General public

Other (specify)

28-DO YOU PLAN TO CREATE A NEW TRAINING / COURSE ON?

Energy efficiency in buildings: ☐ Yes ☐ No
Passive and bioclimatic buildings: ☐ Yes ☐ No
Urban planning: ☐ Yes ☐ No

If yes, please fill out the following form:

DATA COLLECTION FORM
PLANNED TRAINING / COURSE
FORM N° /

1- SUBJECT OF THE TRAINING / COURS

☐ Energy efficiency in buildings
☐ Passive and bioclimatic buildings
☐ Urban planning

2- TITLE

3- TYPE OF THE TRAINING / COURSE

☐ Academic training / course ☐ Professional training / course

Other (specify)

4- DURATION

5- THE OBTAINED DIPLOMA / CERTIFICATES

6- THE BENEFICIARIES:

☐ Managers ☐ Engineers ☐ Architects ☐ Technicians☐ Craftsmen and construction workers

Other (specify)

Mixed (e.g. engineers, managers togeth *specify*

7- THE PROGRAM OF THE TRAINING / COURSE AND CONTENT:

Please join to this form the program and the content of each training / course and send it by e-mai

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