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Proposals for the Thermal Regulation of Buildings in Algeria: An Energy Label for Social Housing

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***Abstract*—**Despite the international commitment of Algeria towards the development of energy efficiency and renewable energy in the country, the internal energy demand has been continuously growing during the last decade due to the substantial increase of population and of living conditions, which in turn has led to an unprecedented expansion of the residential building sector. The RTB (Thermal Building Regulation) is the technical document that establishes the calculation framework for the thermal performance of buildings in Algeria, setting up minimum obligatory targets for the thermal performance of new buildings. An update of this regulation is due in the coming years and this paper discusses some proposals in this regard, with the aim to improve the energy efficiency of the building sector, particularly with regard to social housing. In particular, it proposes a methodology for drafting an energy performance label of new Algerian residential buildings, moving from the results of the thermal compliance verification and sizing of technical systems as defined in the RTB. Such an energy performance label – whose calculation method is briefly described in the paper – aims to raise citizens' awareness of the benefits of energy efficiency. It can represent the first step in a process of integrating technical installations into the calculation of the energy performance of buildings in Algeria.

***Keywords*—**Building, energy certification, energy efficiency, social housing, international cooperation, Mediterranean Region.

I. Introduction

As a part of the strategic partnership on energy that the European Union and Algeria have undertaken since 2015, the Program "Taka Nadifa" (Clean Energy) aims to support the implementation of two Algerian Government programs, namely the National Renewable Energy Program 2015-2030 (PNDER) and the Energy Efficiency Program 2015-2030 (PNEE). At the same time, it supports the national authorities in the realization of an economic model based on energy transition, circular economy and sustainable development. Since 2015, indeed, Algeria is committed at the international level, through the Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change [1], to reduce GHG emissions by 7% by 2030, only based mitigation actions to be implemented internally and planned for the 2021-2030 period. Such target might rise to 22% with international support in terms of finance, technology development and transfer, and capacity building. In this framework, the PNDER and PNEE have been updated in 2016 with the aim to reach 22,000 MW of renewable power installed by 2030 for the national market and to achieve energy savings by 2030 of around 63 million tonnes of oil equivalent (TOE) for all sectors (building and public lighting, transport, industry) [2]. Above all, the building sector is expected to secure the largest energy savings from 2016 to 2030, amounting to around 30 million TOE. The main envisaged measures involve efficient lighting, thermal insulation of constructions and solar water heaters. These initiatives have to consider a significant increase of electricity demand due to the growth in economic activity and the high population growth rate [3]. The last few decades in Algeria have indeed been marked by an unprecedented demographic growth, which has in turn led to a significant development of its construction market. Particularly, Social Housing – executed on behalf of the State by the Ministry of Housing, Urban Planning and the City (MHUV) – has been increasing at a rapid rate due to the development of a diversified public housing offer to replace gradually obsolete suburban stock with precarious living conditions, especially by means of multi-story apartment buildings. Among the housing supply segments, diversified according to the income of the beneficiaries, most are delivered without the technical systems installed. The beneficiary of the housing solution carries out the eventual installation of heating, air conditioning, and domestic hot water production equipment.

A detailed analysis of these programs is provided in [4] and [5], which also bring to the attention several of the current issues that affect the housing sector in the country. One of these is the difficulty to provide meet the growing demand, especially in the low-income segment, where there is no contribution coming from the private sector either, also given the low expected revenues. Another common issue, highlighted in [4], is the lack of technical inspection, which directly influences the quality of housing. As stated in [6], in such context of scarcity of housing, the authorities are more sensitive to the interests of speed than to those of energy efficiency. In other words, while considering budget constraints and the cost of more robust energy efficiency measures, the State preferred to build more, at lower cost. Besides, the highly subsidized price of energy certainly also plays a part in this. In the decade 2009-2019, approximately 3 million new units have been delivered, as shown in Table I, where updated data from the MHUV and from the National Office for Statistics (ONS) are reported [7]-[12].

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TABLE I
SUMMARY TABLE OF THE EVOLUTION OF THE HOUSING SECTOR (2009-19) [7]-[12]

	2008	2019
Housing Stock	6,872,541	9,845,692
Population (ONS)	34,080,030	43,900,000
Urbanization Rate	65.77%	70.00%
Housing Occupancy Rate	5.1	4.46

Looking at the data in Table I displaying the strong increase in population and the growth of the housing stock, predictably in Algeria final energy consumption in the residential sector has grown steadily in the last years. The building sector amounts to the largest share of energy consumption in Algeria (43%) and, in particular, the residential sector accounts for over 33% of the total, with a constant increase over the years [13]. In particular, the growth in electricity consumption also reflects a change in consumer behaviour that drives electricity demand, which could also be explained by the highly subsidized low electricity prices [3]. Having said that, it is evident that implementing energy efficiency and renewable sources in the building sector, especially in the residential sector, represents a noteworthy opportunity to limit energy consumption and greenhouse gas emissions in the country. It can generate multiple social, economic and environmental benefits for the homeowners and beneficiaries of the Social Housing programs as well as for the State. At the same time, a significant shift is also necessary in consumers' behaviour: raising public awareness about the advantages of energy efficiency and promoting more energy-conscious behaviours is of extreme relevance. Reference [14] shows how simple impact indicators, which can be made available to homeowners to reveal tangible benefits of specific energy efficiency measures, can serve as intrinsic economic, environmental and social motivators for pursuing energy efficiency, under both the market-based pricing structure for energy in Germany and the state-subsidized pricing structure in Algeria.

The regulation that in Algeria guides building designers in the calculation of the thermal characteristics of buildings and for the realization of efficient buildings is the "Document Technique Réglementaire C.3.2/4" [15], from now on referred to with the acronym RTB (Building Thermal Regulation). This document was published in 2000, revised in 2016 and a new revision is expected in the coming years.

The paper firstly discusses the results of the analysis of the RTB, underlining main issues to be addressed in order to enhance its application. Then, it discusses some proposals for an update of the RTB with the aim to improve the energy efficiency of the building sector in Algeria, for both new and existing buildings. Particularly with regard to social housing, a methodology for drafting an energy performance label of new Algerian residential buildings is finally defined based on the results of the thermal compliance verification and sizing of technical systems as defined in the RTB and is thoroughly described in this work.

II. THE THERMAL REGULATION OF BUILDINGS IN ALGERIA

The main document that needs to be addressed when considering the energy efficiency of buildings in Algeria is the RTB. The RTB provides all necessary guidance and information for building thermal performance evaluation (from climate data to thermo-physical properties of building materials, etc.). For example, it introduces the methods for calculating the heat gains and losses through the building envelope as well as for the sizing of minimal heating and cooling power.

In order to consider the peculiar variability of Algerian climate, ranging from dry and desertic in the centre and in the south to temperate in the north [16], the RTB identifies every location in the country by means of two distinct climate zones, one for winter and the other for summer conditions. According to these, the thermal performance of buildings is calculated. In particular, five climate zones (A, A1, B, C, D) are designated for winter climate and nine (A, B, B1, B2, C, D, E, E1, F) for summer climate. The weather and thermal parameters associated with each zone are therefore associated with the building location and utilized for every calculation in the RTB. Unlike in the coastal areas – whose climate can be easily associated e.g., with that of southern and insular Italy – in the largest part of Algeria seasonal differences can be rather large and thus it is very important to consider two climate zones.

Another aspect to underline when analysing Algerian climate is the great solar energy potential. Across the whole country, the global horizontal solar irradiation (GHI) ranges from around 1,600 to 2,500 kWh/m^2 per year that corresponds to a photovoltaic (PV) electricity production potential for horizontal surfaces from about 1,500 to 2,100 kWh/kWp per year [17]. It is a large potential, if we compare these numbers e.g., with those of Germany, where the sunniest areas show a GHI lower than 1,300 kWh/m^2 per year: nevertheless, Germany is the fourth country in the world and the first in Europe in terms of installed PV power, which reached 49,200 MW in 2019 [18].

Most importantly, the RTB has introduced a concrete measure aimed to impose minimum thermal insulation for building envelope components and, as a result, to stimulate the energy efficiency of new buildings. That is the establishment of mandatory thermal compliance checks for the building envelope of new constructions in both winter and summer conditions. In particular, the thermal regulation sets thresholds not to be exceeded for the thermal losses through the envelope during winter and for the thermal gains during summer.

For a more detailed analysis of the thermal compliance verifications, the reading of the regulatory text [15] is advised. Here, it is deemed of relevance to underline a few aspects that should be taken into account while revising this regulation, in order to make it more effective and to enhance its application. Firstly, the requirements that derive from the RTB are only in force for new buildings, whereas a large energy efficiency potential in Algeria also lies in the energy renovation of the existing building stock. Furthermore, at present, the thermal compliance verification is compulsory for all new buildings, but, in fact, the control of its achievement is only done at the request of the building owner and not by default. Such lack of control over the thermal compliance results in poor enforcement of RTB requirements.

Finally, the RTB verifications only entail the building envelope performance, whereas to estimate the energy consumption of a building, it would be necessary to consider the operating performance of technical systems. The regulation provides a methodology for sizing heating and air conditioning systems, but it does not deliver indications on technologies or on minimum efficiency values for building technical systems (e.g., for heating, cooling, domestic hot water production…).

III. Proposal for a Revision of the RTB

In line with the considerations made in the previous paragraph, a proposal to strengthen the implementation of the RTB should:

1. Extend the thermal verifications also to the refurbishment of existing buildings;
2. Condition the obtaining of the building permit to the achievement of the regulatory thermal verifications;
3. Account for the efficiency of the technical systems to be installed when evaluating the "potential" energy performance of a new building.

In order to extend the thermal performance obligations to the existing building stock, two possible approaches could be pursued. On the one hand, each building component that undergoes a major renovation might be subjected to thermal transmittance limits in accordance with the reference coefficients defined in the deputed table in the RTB. For example, if the roof of a building needs to be replaced or restored in a significant portion (e.g., higher than 50% of its total surface), a minimum thermal insulation should be guaranteed and the tabulated values provided for roofs in the RTB should provide the reference in this sense. On the other hand, the thermal compliance verifications could be made compulsory for all buildings that are subjected to "major" renovations (for example, entailing more than 50% of the envelope surface and/or interventions on the technical systems for heating, cooling and domestic hot water production). The condition to define a renovation as "major" should be discussed more in detail. The definition provided in the Italian Decree 26/06/2015 could be of reference in this sense [19].

In the complex procedure for obtaining a building permit for any building typologies in Algeria, there is no specific control of compliance to the RTB and there is no obligation to submission of a RTB compliance report from the developer (*Maître d'Ouvrage*, or *Maître d'Ouvrage Delegué* in social housing). As a result, the application of the prescriptions of the RTB has been limited in the country. The second proposal for an update of the RTB is to integrate a "thermal compliance report" among the documents to submit, in the executive design phase, to the Algerian National Body for Technical Control of Construction (CTC) for the approval of the building permit file (including the civil and architectural designs, etc.). After this approval, nothing else changes in the process and the documentation is subjected to the other necessary controls until the start of construction. Such a simple proposal should easily enhance the application of the prescriptions of the Thermal Regulation in the country, significantly stimulating basic yet effective thermal insulation measures for the energy efficiency in the building industry.

As already pointed out in the previous section, the RTB does not provide designer with significant guidance when it comes to the selection of technical systems for heating, cooling and domestic hot water (DHW) production as well as to the calculation of their performance. In this framework, the paper proposes a first exercise of building energy performance certification (based on a "standard" utilization of the technical systems), which could well apply to the new residential buildings in the coming years. The so-called APPE (Attestation of the Potential Energy Performance of a building) was designed in this first phase for that large share of newly built social housing units in Algeria that are delivered without technical systems. The energy performance that is calculated through the APPE is thus "potential", because it depends on the choice of technical systems for air conditioning, heating and DHW production. This choice is made by the beneficiaries/users of the housing unit. The APPE is designed to make these subjects aware of the challenges of energy efficiency and of the savings that would result from the most efficient choices, by giving an indication of the primary energy consumption due to heating, air conditioning and DHW production, depending on the climate zone, apartment characteristics and technical solutions to be installed. It is worth to specify that the APPE does not provide the actual energy consumption of a housing unit, but rather the energy consumption related to a use of the apartment and of its technical systems that is "standard", i.e., equal for all housing in the same area.

A. Attestation of the Potential Energy Performance

The calculation methodology of the APPE has been designed for an easy implementation that starts from the results of the compliance verification and that follows the steps shown in Fig. 1. The steps are briefly described in this section, but the detailed calculation might be the object of a future paper.

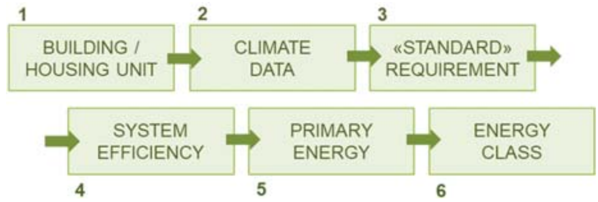

Fig. 1 The steps of APPE calculation

Firstly, the housing unit whose APPE is being calculated must be defined in terms of geometry and envelope features, and its thermal performance is evaluated according to the RTB. Clearly, the thermal compliance is a precondition for advancing the calculation of potential energy performance. The sizing of the technical systems for heating and cooling – carried out according to the RTB – represents the basis for the calculation of heating and cooling energy requirements.

Given that the RTB only provides power (kW) values, in order to obtain the respective energy requirements (kWh), it is necessary to estimate the time required to the technical systems operating at nominal power to be able to ensure the comfort temperature inside. The additional climatic data necessary to do this are the Heating Degree-Days (HDD) and Cooling Degree-Days (CDD). These are in turn calculated from the average temperature of each day of the year in the locality where the housing unit is situated. This latter value, which is not provided in the RTB, was calculated from hourly temperature data obtained from [20] and referring to a 10-year period. Moreover, in order to evaluate the "standard" energy requirements for DHW production, another climate information is necessary, i.e., the monthly average temperature (T_m). The latter derive from the average monthly temperature data, obtained from the numerous climatic stations reported in the RTB.

Once the necessary climate data are gathered, it is possible to evaluate the "standard" energy requirements for the three services that the APPE has to account for (heating, cooling and DHW production). Finally, the annual energy need for DHW production is easily calculated in function of the surface area of the apartment and the monthly average outside temperatures of its location (T_m), according to the procedure pointed out for residential buildings in the Italian technical regulation [21]. Then, a selected catalogue of technical systems for heating, air conditioning and DHW production has been drawn up (Table II) and to each item minimum generation efficiency values have been assigned, starting from the corresponding values in the Italian regulation [19] and from the observation of recurring technologies in the Algerian market. Thanks to numerical simulations made for each of winter climatic zones (which correspond to different external base temperatures), the coefficients of performance (COP) of electric heat pumps for heating and DHW production were diversified according to the winter climatic zone, by means of energy simulations on different apartments in distinct Algerian cities.

In parallel, the APPE also accounts for solar renewable potential through a simplified method. As for PV, it considers a power of 1 kWp per dwelling and uses annual average production values in kWh/kWp, obtained from [23], to evaluate the unit PV production. This is expressed in kWh of electricity per m^2 of housing area. As for the Solar Thermal (ST), the APPE considers an 80% coverage of DHW requirements of each of the analysed housing units.

Once the generation efficiency values are set and the combination of the technical building systems for the housing unit is chosen, it is possible to move from the annual energy requirements for heating, cooling and DHW production to the respective annual primary energy consumption per square meter of housing (kWh/m^{2}yr). This depends on the annual standard energy requirement (kWh), the useful floor area of the housing unit (m^2), and the primary energy conversion factor. This latter accounts for the amount of primary energy required to produce 1 kWh of the final energy in use in the apartment to power the chosen technical system (natural gas or electricity).

Finally, the annual global primary energy consumption per square meter of housing EP_{GL} (kWh/m^{2}yr) is the result of the sum of the annual primary energy consumption for heating, cooling and DHW production and it is the factor underlying the (potential) energy classification. The energy classes and the corresponding EP_{GL} values are obtained based on predefined combinations of technical systems for heating, air conditioning and DHW and "per dwelling" (as shown in Table III). This means that each dwelling has a specific energy classification depending on its location, geometry and envelope characteristics. The same combination of technical systems always corresponds to the same energy class, but in different dwellings and in distinct climatic zones each combination and energy class corresponds to different values of EP_{GL}.

As follows, the paper briefly evaluates two case studies with the aim to illustrate the proposed classification and show the wide range of possible results. One is a middle-floor apartment in a multi-story residential building (whose features have been defined by the authors) from now on also referred to as "apartment"; the other one is a single-family house (taken from [24] as for its geometry, but modified by the authors for the scopes of this study). Their main features are synthetized in Table IV.

TABLE II
MINIMUM GENERATION EFFICIENCY OF THE LISTED TECHNICAL SYSTEMS

Heating			A	A1	B	C	D
Electric Heat Pump	COP	-	3,73	3,87	3,87	3,40	4,02
Methane Heat Pump	GUE	1,2	-	-	-	-	-
Condensation Boiler	η_{gen}	0,95	-	-	-	-	-
Modulating Boiler	η_{gen}	0,905	-	-	-	-	-
Gas Heater	η_{gen}	0,88	-	-	-	-	-
Electric Heater	COP	1	-	-	-	-	-
Cooling							
Electric Heat Pump	EER	2,5	-	-	-	-	-
Methane Heat Pump	GUE	1,1	-	-	-	-	-
DHW production							
Electric Heat Pump	COP	2,5	2,26	2,39	2,51	2,16	2,51
Condensation Boiler	η_{gen}	0,8	-	-	-	-	-
Standard Boiler	η_{gen}	0,7	-	-	-	-	-
Electric Water Heater	COP	0,35	-	-	-	-	-

TABLE III
TECHNICAL SYSTEMS ASSOCIATED TO THE DIFFERENT ENERGY CLASSES

A^{++}	Electric Heat Pumps for H, C, DHW + ST and PVs
A^{+}	Electric Heat Pumps for H, C, DHW + ST
A	Electric Heat Pumps for H, C, DHW
B	Condensation Boiler for H and DHW and Electric Heat Pump for C
C	Modulating Boiler for H and DHW and Electric Heat Pump for C
D	Modulating Boiler for H, Electric water heater for DHW and Electric Heat Pump for C
E	Less efficient solutions

Along with the main features of the case studies, Table IV also displays the thermal results obtained from the online tool CTBAT [22], made available to the public by the Algerian Agency for the Promotion and Rationalization of Energy Use (APRUE). Both case studies are compliant to the RTB, that is set as a prerequisite for the APPE calculation and, in general, it is compulsory for all new Algerian buildings. The winter and summer climate zones are A in both case studies.

TABLE IV
RELEVANT ENERGY DATA REGARDING THE TWO CASE STUDIES (INPUT)

	Apartment	Single-family House
Dimensional features		
Useful floor surface (m^2)	88.4	68.2
Volume (m^3)	278.1	240
Envelope Surface (m^2)	93.75	272
S_{ENV} / V	0.3	1.1
Thermal transmission losses – D_T (W/°C)	66.87	221.64
Reference thermal losses – D_{REF} (W/°C)	146.96	443.12
Heating Power (kW)	2.2	5.7
Heat gains through the envelope – $\Sigma APO+\Sigma AV$ (W)	559.61	2,125.51
Reference Heat gains – $\Sigma APO_{REF}+\Sigma AV_{REF}$ (W)	1,074.74	2,516.91
Cooling Power (kW)	1.3	3.1

The energy classification scales of the analysed case studies are shown in Fig. 2, where a large difference in terms of energy performance is clearly noticeable, despite them being in the same climatic zones. In the APPE classification, each combination of technical system always corresponds to the same energy class. Hence, an all-electric combination based on heat pumps for heating, cooling and DHW production is always in class A, but the associated consumption depends on the location of the dwelling and its features. Particularly, in this case, the S_{ENV}/V ratio is the most relevant parameter, leading to higher heating and cooling power for the single-family house compared to the values of the apartment.

Fig. 2 Energy classification scales of the two case studies (apartment in multi-story building, on the left, single-family house, on the right) situated in the same climate zone

A possible layout of the APPE certificate has been drafted, including: general information about the housing unit; a catalogue of possible technological solutions for heating, cooling, and DHW; the outputs of the APPE for a number of possible technical system combinations (energy class, primary energy consumption, CO_2 emissions, etc.). Tables V and VI summarize the outputs of the APPE for the two case studies.

TABLE V
OUTPUTS OF THE APPE FOR THE TWO CASE STUDIES EQUIPPED WITH AN ALL-ELECTRIC HEAT PUMP COMBINATION OF TECHNICAL SYSTEMS

Case-Study Apartment	DHW	Heating	Air conditioning
Technical system	Electric Heat Pump	Electric Heat Pump	Electric Heat Pump
Final Energy	6.2 kWh_{EL}/m^2y	14.5 kWh_{EL}/m^2y	4.0 kWh_{EL}/m^2y
Primary Energy	15.4 kWh/m^2y	36.4 kWh/m^2y	9.9 kWh/m^2y
ST		PVs	
Primary Energy for DHW with ST	3.1 kWh/m^2y	Share of PV in % of electricity	73%
	With PV	With ST	Without PV&ST
Energy class	A++	A+	A
Primary Energy	17 kWh/m^2y	49 kWh/m^2y	62 kWh/m^2y
Single-Family House	DHW	Heating	Air conditioning
Technical system	Electric Heat Pump	Electric Heat Pump	Electric Heat Pump
Final Energy	6.7 kWh_{EL}/m^2y	48.8 kWh_{EL}/m^2y	12.3 kWh_{EL}/m^2y
Primary Energy	16.7 kWh/m^2y	122.1 kWh/m^2y	30.7 kWh/m^2y
ST		PVs	
Primary Energy for DHW with ST	3.3 kWh/m^2y	Share of PV in % of electricity	34%
	With PV	With ST	Without PV&ST
Energy class	A++	A+	A
Primary Energy	111 kWh/m^2y	156 kWh/m^2y	170 kWh/m^2y

TABLE VI
OUTPUTS OF THE APPE FOR THE TWO CASE STUDIES EQUIPPED WITH A LOW-EFFICIENCY COMBINATION OF TECHNICAL SYSTEMS

Case-Study Apartment	DHW	Heating	Air conditioning
Technical system	Electric Water Heater	Modulating Boiler	Electric Heat Pump
Final Energy	39.9 kWh_{EL}/m^2y	59.9 kWh_{GN}/m^2y	4.0 kWh_{EL}/m^2y
Primary Energy	99.7 kWh/m^2y	62.9 kWh/m^2y	9.9 kWh/m^2y
ST		PVs	
Primary Energy for DHW with ST	19.9 kWh/m^2y	Share of PV in % of electricity	41%
	With PV	With ST	Without PV&ST
Energy class	D	C	E
Primary Energy	128 kWh/m^2y	93 kWh/m^2y	173 kWh/m^2y
Single-Family House	DHW	Heating	Air conditioning
Technical system	Electric Water Heater	Modulating Boiler	Electric Heat Pump
Final Energy	43.2 kWh_{EL}/m^2y	201.3 kWh_{GN}/m^2y	12.3 kWh_{EL}/m^2y
Primary Energy	107.9 kWh/m^2y	211.4 kWh/m^2y	30.7 kWh/m^2y
ST		PVs	
Primary Energy for DHW with ST	21.6 kWh/m^2y	Share of PV in % of electricity	42%
	With PV	With ST	Without PV&ST
Energy class	D	C	E
Primary Energy	292 kWh/m^2y	264 kWh/m^2y	350 kWh/m^2y

Table V displays the potential energy performance of the two analysed case studies, when considering them equipped with, for example, electric heat pumps for all three services. Table VI instead shows the result of the same case studies equipped with a less energy efficient combination of technical building systems: i.e., an electric water heater for DHW production, a standard modulating boiler for heating and electric heat pumps for air conditioning. The comparison between Tables V and VI shows how diverse the results in terms of energy classes (ranging from A++ to E) and primary energy consumption can turn out, even in the same housing unit, depending of the selected combination of technical systems. On the other hand, each of those tables demonstrates that the thermal and geometrical characteristics of each housing unit are responsible for the wide range of results in terms of primary energy consumption, even within the same energy class.

The objective of this type of approach is to treat in a specific way each building/housing unit, without imposing absolute values that would penalize certain configurations of buildings and climate locations. Regardless of these, if the chosen technical system is the same, the associated energy class should be the same, even if the associated primary energy consumption can be very different

IV. Conclusions and Future Insights

The effort that Algeria is dedicating to the development of Social Housing is an opportunity not to be missed to increase the weight of energy efficiency and renewable energy sources in the national energy mix. Although with a certain delay compared to European countries, the country has put in place a set of technical regulations for energy efficiency in buildings and is targeting growingly ambitious objectives. Starting from a study of the Algerian Thermal Regulation of Buildings, this paper introduces a series of proposals to enhance the application of the RTB in the country.

In parallel, the paper presents a possible energy certification system, in a first phase targeted towards residential buildings, which represent the largest sector in Algerian construction market, with the largest potential of energy saving. The proposed methodology has been conceived to be easily implemented starting from the results of thermal compliance verification according to Algerian technical regulation. The methodology that is briefly introduced in the paper is based on the evaluation of "standard" heating, cooling and DHW production requirements, starting from a set of climate data that are available or can be easily, with some approximation, made available for the whole country.

The primary energy results, which serve for the energy classification of each housing unit, are obtained by considering typical climate data for each location and a standard usage of building systems in terms of hours of operations. Hence, results are not linked with actual consumptions: these in turn depend on several aspects, from the actual usage of the dwelling and its systems to real weather conditions that change every year. However, results provide a comparative indication of where actual energy consumption is expected to be higher or lower.

As discussed, the energy classification system is aimed to orient decisions towards the most effective technical systems: therefore, regardless of the widely varying primary energy consumption ranges, the most efficient combinations will always be awarded with the energy class of the highest level.

The APPE is seen as an excellent opportunity to raise citizens' awareness about some of the benefits of energy efficiency. It can represent a first step in a gradual process of integrating technical systems into the calculation of building energy performance and it may finally help implement financial support mechanisms for the most effective and advanced solutions for building technical systems on the market.

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