A low-tech approach to nZEB dwellings in developing countries - case study Romania

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Abstract. This paper, based on a larger research, focuses on evaluating the feasibility and challenges of implementing the nearly Zero-Energy Building (nZEB) standard on dwellings in Romania. It is proposed that implementing this new set of regulations and national strategies should be context-specific, adapted to several factors which are common to a particular area in regard to the characteristics of housing and dwelling: the culture of dwelling, the dynamics of dwelling (occupancy, maintenance, use), household finances and expenses, demographics, building habits and the construction market and climate considerations. These realities are however a product of long periods of evolution and a result of certain habits. The new paradigm, oriented towards energy efficiency, is in some regards divergent to these. As such, before using advanced technological means for a more energy efficient building, these traditions and habits should be addressed. There should be a focus on the initial stages of the design (regarding the future building) and on the way it is used, which means that the architect and the end-user (the dweller) are central to the process. Initial decisions about the appearance of the building and how it is built (orientation, building materials, internal layout etc.) and involving the future dwellers and their dwelling habits in the process affect the overall energy footprint of the building in a more decisive manner than later technological additions. As a result, a context-specific low-tech approach to energy-efficient dwellings begins to take shape. Rather than being localized, it will be shown that these new strategies can affect much larger areas, even involving shifts in the way human settlements are designed and managed.

1 Introduction

In light of the growing concerns about pollution and its impact on the climate, concrete measures to reduce it are being enforced in many domains. Of special interest is the building sector, particularly the one regarding residential buildings, as it is estimated that they use about 22% of the total energy consumption worldwide and are responsible (directly or indirectly) for about 17% of CO2 emissions [1]. Additionally, there is also the construction
industry which further adds to this percentage. As a result, there is a growing number of initiatives that try to curb these trends, which keep growing in the meantime.

One of these initiatives is the European Directive EPBD 2010/31/EU which imposes to the member states to adopt the nZEB (nearly zero-energy buildings) standard by 31 December 2020. This type of building is being defined as an energy efficient system whose energy demands should be covered in a great percentage by renewable sources. The definition is purposely lax and the rules of its implementation in a national context are left to be devised by each country according to its specifics [2]. Basically, it can be reduced to two indexes: a maximal amount of energy used by each residential unit and a minimum percentage of energy extracted from renewable sources.

In the case of Romania, adopting this directive was slow and it is still not fully implemented. The most recent two guidebooks were published in November 2022 [3], addressing both newly built constructions and existing ones, yet the specific energy efficiency targets to be met are still absent. Preceding these guides, in 2019, there was a research sponsored by the Romanian government through European funds [4] which was specifically aimed at the residential sector. Its scope was to lay some context-specific guidelines for a set of public policies which could be used by the involved state entities to plan a larger national strategy regarding these matters. The current paper is based on that research.

The dwelling is a particularly complex matter to change since it lies at the core of human existence. Actual dwellings and the way they are used are the result of long standing and evolving traditions and are dependent on a complex system composed of several factors, climatic, economic, social, industrial, administrative etc. As a result, changing the way a dwelling is designed, built and inhabited means affecting several key components of an economy and of a society. It is a context-sensitive topic. As a result, a bottom-up approach seems more feasible, heavily dependent on actual realities at a local level and designed with the key actors in mind: dweller, architect and builder.

Due to the vast amount of information involved, this paper will only focus on newly built individual dwellings in an urban or rural context and will not approach specific regions, rather it will focus on general principles.

The study is organised in two main parts. The first part deals with the specifics of Romanian context: the physical state of the dwellings and their energy profile, the financial aspects of the households, expenses and investments and the dwelling habits, as part of the dwelling culture. The second part illustrates some key aspects of a strategy for energy efficient dwellings, tailored around the conclusions derived from the first part. It will be shown that, in the case of Romania, a low-tech/low-cost approach is more feasible, together with some possible new approaches.

2 The Romanian context

A study of the dwellings in a specific region will always have to take into account both the building itself and the way it is used (inhabited). The study of these two concurrent aspects will also reveal certain characteristics of the broader context, based on which some conclusions emerge which are relevant when discussing a strategy that aims to change or adapt them. It will be shown that the building and the way it is inhabited are interdependent and that they affect each other, forming a self-propagating cycle which can improve or worsen a situation. The case of Romania has also some interesting characteristics which set it apart from other European examples and could help shape a future strategy for energy efficient dwellings.
2.1 The state of the dwellings in Romania

Seen from a historical perspective, the housing stock in Romania can be loosely organised in three main layers: a period before 1945, a period between 1945-1990 and a period after 1990. Each period corresponds to a specific way of economic and social development. Before 1945, especially the interwar period, was defined by a process of modernisation after a western model, a shift from an agrarian, rural society towards an urban model. It was a slow process, ruled by the free market and by some localised state initiatives. Between 1945-1990 there was a new economic and social system, when there again was a shift, this time towards a soviet model, that later developed its own specific overtones. In this period there was a long process of forced urbanisation which tried to erase centuries of rural way of life and force a collectivist model, with few privately owned dwellings. In this period the private initiative was minimal and massive state investments were made towards the construction of collective dwellings, seen as a symbol of the new state and man. After 1990 there again there was a major change, towards a capitalist market and a western way of life. This last period sees an abrupt deindustrialization. Coupled with it there was a decline in the housing market due to a reduction of state investments and a sharp increase of the housing prices in light of the new free market. As a result, there is a vast majority of dwellings which dates from the intermediate period, 1945-1990, especially between 1961-1980 [5]. In 2017 there were only 10% of dwellings built after 1990 [6], equally distributed between the rural and the urban settings [7]. The public investments in new dwellings saw a sharp reduction after 1990, with as high as 88% between 1990-2000 [8]. Only after 2000, as a result of introducing housing schemes for young people and underprivileged persons, the rate of public investment in dwellings saw a slight increase to about 2000 units per year [8].

The rate of replacing the built environment is low and upgrading it is hindered by the high living costs of the households. It is a cycle that is self-perpetuating. As a result, the severe housing deprivation rate index for Romania in 2016 was as high as 20%, compared to a European average of about 5% [9].

There is also a phenomenon which is widespread in Romania, that of building without a permit. As a study shows, in 2019 there were around 24 bureaucratic procedures needed and around 260 days necessary for obtaining a building permit [10]. This slow and cumbersome process coupled with a generally low capacity for investment means that building without a permit is an option regarded as acceptable. There is a lack of studies in this domain, yet it is a very common occurrence. This means that there is also a developed black market of materials and of manpower, the result of which can be seen in the conditions of the buildings which have from the start problems of quality and maintenance. Seen by the type of property, both in the urban and the rural settings there was a percentage of over 90% of dwellings in private ownership [8], compared to a European average of 69% [9]. These numbers are however approximate, since the rental market is somewhat unregulated and the real number of tenants is therefore vague [8].

This data shows an important characteristic of the Romanian housing market, one which has important implications in the discussion about energy efficiency of the dwelling: there is a vast majority of dwellings which are privately owned. This trait means that the population will make considerable efforts towards owning a dwelling, for a personal use or seen as an investment. The reasons are both traditional, owning a house is something that has always been the normality, a statement of one’s statute and identity, and existential, because in an unregulated rental market and in an economy that is unpredictable, owning a house is a reassurance of one’s survivability even in times of crisis.

Regarding the type of the dwellings, in 2015 the studies showed 98% of individual dwellings in rural setting and 70% of collective dwellings in the urban setting [5]. There is an important fact that should be added. The households in the rural area are generally placed in the lower zone of the income categories. This means that lower income households tend
to inhabit preponderantly individual dwellings which are the most expensive dwellings in terms of building, acquiring and maintenance.

The size of the dwellings is, in average, of 2 rooms in urban settings and of 3 rooms in rural settings [11]. In terms of the average living surface, the area is of 47 sq. m, compared to 102 sq. m at the European level, which translates to an average of 20 sq. m / person, compared to 34 sq. m / person in Europe [11]. There is, it seems, a tendency for overcrowding, a phenomenon which is linked with certain aspects of financial and cultural traits which will be discussed in the following section [5].

The constructive system preferred is the load-bearing masonry wall (AAC, brick), which is used in both the urban and rural settings, followed by reinforced concrete structures. Light structures, such as wood or steel, only represent 1% of the total [12]. The use of other constructive systems, more oriented towards energy efficiency, are minimal. An interesting aspect is that the type of construction method doesn’t really differ between urban or rural, nor between the different regions. Therefore, it seems, local conditions which usually influence the choice in materials are not that important in this case and construction models which are generally inherent to urban areas are preferred even when the dwelling is built in a rural setting with its own specific resources.

The energy profile of the dwellings refers to the amount of energy used for heating, ventilation, warm water, lighting, appliances etc. In Romania, there were no regulations regarding thermal insulation until the 70’s energy crisis and modern norms were only introduced in 2005. This means that there is presently a built environment which is largely unsuited to modern norms of energy efficiency. Some estimates place the energy consumption of a dwelling as high as 400 kWh/year [13]. Looking at a household’s energy consumption patterns, the greatest percent is channelled towards heating (57%), followed by warm water (32%), lighting (2%) and appliances (9%) [13]. Other data shows that the energy demand required for heating was of 55% in apartments and 80% in individual dwellings [13]. This model of energy consumption distribution is typical to developing countries where the high energy demands are required for heating, compared to the developed countries where the highest energy demand is required for appliances and lighting since the needs for heating are reduced due to energy efficient dwellings [14].

### 2.2 The financial profile of the households – the energy poverty

The summarised data presented thus far addressed the physical aspects of the dwellings. It shows a built environment which is predominantly older than 40 years, thus in need of increased maintenance and a majority of the buildings that are not sufficiently equipped to handle minimal energy efficiency standards. There is a preponderance of privately owned dwellings, a type of dwelling that is expensive to build and to maintain. In order to lower the construction costs, the people often resort to building cheap and sometimes even without a building permit.

All these facts point to a situation that puts pressure on the household finances. Analysing the data, this fact becomes clearer: in 2012 the basic expenses related to the dwelling (paying the bills and the taxes, reimbursing the credit etc.) were at over 40% of the household’s income [9], while 36% of them had trouble paying the utilities bills on time [15]. This means that there is a reduced capacity to invest in one’s dwelling, for upgrading it or for basic maintenance. Yet the built environment keeps getting older and new dwellings are being constructed only at a rate of 1% per year of the total exiting ones [11].
A household’s inability to access essential energy sources (products and services) required for a decent living makes it vulnerable and puts it in a position of energy poverty [16]. It is a phenomenon that is directly linked to the broader problematic regarding the energy efficiency of the dwellings. Its causes are multiple, a deficient infrastructure, an unregulated market which causes high prices or abusive commercial practices, several socio-demographic factors (age, ethnic, education etc.) which can lead to a state of vulnerability and energy inefficient dwellings, with inadequate appliances and heating systems or which are poorly insulated [17]. Additionally, countries in South-Eastern Europe inherited a series of traits from their communist past, with its centralized economic model. With a high reliance on polluting energy sources, with a state that is directly involved in several energy companies, with continuous energy subsidies which are based on scarce data and with an aging housing stock, the level of population which finds itself in energy poverty is as high as 40%, one study finds [18]. In this study it is argued that the prices of energy are not decisive for this situation, as Romania has one of the lowest energy prices in EU, but rather it is a larger systemic problem which involves the other factors as well.

Romania tries to address these issues by offering mainly financial subsidies for heating and for electric energy. It is interesting to note here that the amount of subsidies offered by the state in 2017 to help the households was highest for heating with wood and lowest for electric energy [17]. This is relevant in light of a low access to the electric energy grid and to adequate heating systems. This is also one possible explanation for an abnormality in regard to the household’s expenses related to their energy bills: there is a number of households which have low expenses, a thing which is unusual given the fact that they are part of the possible vulnerable category [17]. It can be explained by the fact that there is an unknown number of households which operate outside the regulated energy grid, they use alternative, improper means or don’t access it sufficiently in order to reach an optimal level of comfort.

### 2.3 Overcrowding and underuse

A cumulative effect of the high financial resources allotted to owning a dwelling and the subsequent expenses with energy and maintenance leads to a phenomenon called overcrowding. In 2015 Romania had the highest overcrowding rate in the European Union, with 49.7%, compared to 16.7%, the European average [11]. The average living surface was of about 47 sq. m with an average 2.7 inhabitants/household, compared to an average of 102 sq. m and 2.3 inhabitants / household in Europe in 2014 [19]. There are two possible causes for this tendency for overcrowding.

First, due to reduced financial means, but with a high appetite for owning a dwelling, young members of a household postpone moving out of their parents’ house. In 2017 there were almost 80% of 16 to 29 years old people who still lived with their parents [20]. There is of course also a matter of absorbing them in the labour market due to precarious education, lack of jobs available etc. There has been observed however that 45% of the young employees still live with their parents [21]. There is also the situation where they live with their elder parents in order to care for them in light of a lack of proper social services in Romania. Over 30% of the households contained more than three adults, compared to a European average of only 18% [22].

There is an obvious cultural aspect to these choices, coupled with outside conditions that strengthen them. The family is seen as a social group with a higher capacity to access resources and to sustain itself, a trait that is mostly seen in the rural areas [21]. There is also the expectation for a privately owned dwelling, which is usually bought with saved money, rather than bank credits. Bank credits are seen as a potential liability and have also high interest rates in an economy that is unpredictable and in a job market that has employment issues.
A second cause for overcrowding derives partially from the first one. Accessing a decently sized dwelling is hard with saved money alone, so the first dwelling bought is usually small and inadequate in the broader perspective of starting a family. Being privately owned means that the family’s capacity to adapt and be mobile is greatly reduced. This leads eventually to overcrowding.

There is also a question of diversity of the housing market. The capacity of the housing market to respond to the various expectations is limited. The majority of the housing stock dates from before 1990. The ones built by 1945 are usually situated in the centre of the cities, are expensive and have high maintenance costs due to their age. The dwellings which were built between 1945-1990 were mass-produced and are limited in type. Although standardisation and serialisation offered affordable housing, its downside is a lack of necessary diversity in a society which became much more complex after 1990. What was produced after 1990, was mostly built by private investors and in urban areas and with high profit margins, so they also are limited, do not cover the various needs of the population and are generally expensive. Social dwellings could be the answer, there are however few state programs for social dwellings. In 2011 there were only 120,000 dwellings owned by the state, the majority of which were in the urban areas [22].

In the opposite direction, there is a phenomenon of under usage of the dwellings which is not sufficiently studied. This occurs in several situations. The more frequent one is when elder people inhabit dwellings which are too large for their capacity to sustain them financially. This happens usually after the children move out or when they remain alone.

There are regions which have a greater degree of under usage of their housing stock and others which face a shortage of dwellings. This is due to the fact that the number and type of dwellings are not necessarily linked to the job market and also because the process of suburbanisation means that peripheral settlements absorbed by the cities grow larger while the cities themselves are depopulated [23]. Migration (national and international as well) is another factor that led to ample depopulated regions. By comparing the number of households and the number of dwellings in 2011, 17% of them seemed to be vacant, in other words owned but not occupied [11]. There are also the households which own more than one dwelling, however this is a localised phenomenon.

Overcrowding means overusing the dwelling and leads to higher attrition rates and higher expenses. Underuse means too high energy costs and maintenance for a household. At the inhabitant’s level, it means that the capacity to maintain and invest in one’s own home is limited and dealing with the monthly expenses is difficult.

3 A low-tech approach to energy efficient dwellings in Romania

A house is a complex system which is dependent on a number of factors: there are site specific circumstances, there is a larger system of infrastructure (energy distribution grid, water and sewage, construction industry), the decision makers (local institutions, law makers) and the specialists (architects, engineers, builders) and there is the actual inhabitant which uses and maintains this system. In other words, in order for a dwelling to come into existence and to function properly, it depends both on external factors (economic, industrial, legislative, specialists of various fields, site specific conditions etc.) and on internal factors, the human and the actual way it is used. A way a dwelling is built and used is something which is usually well established in a culture, so changing it requires a multipronged approach addressing each element involved.

Achieving an energy efficient dwelling represents such a shift of mentalities. There are generally two paths to achieve energy efficiency: a high-tech approach, which is characteristic to developed countries which already have a long tradition in this domain and a low-tech approach, more suited to developing countries [14]. The second approach, it is
argued, is more suited to areas of lower economic potential, with an underdeveloped construction industry, because it is a method which is more adaptable and which utilises local resources in a more efficient manner. The low-tech approach relies in a greater extent on passive strategies which refer basically to orientation of the building, form, envelope and inner layout, in order to achieve proper heating or cooling and lighting. Technological additions are introduced only as needed, to supplement or to regulate.

As shown in the previous part, in Romania there is a strong culture of owning a dwelling, which is an important trait of its culture, with the house placed at the core of the family. This should be therefore a starting point of a discussion about energy efficient dwellings in Romania.

Owning a dwelling means it should be cost effective to build, to maintain, it should be energy efficient and should be flexible enough to adapt to various changes in the household. It should be a dwelling which was specifically designed with these aspects in mind. This is an important point because architects, engineers and builders have their own traditions and habits, which now have to encompass these features as well.

Then there is the issue of energy sources. Accessing a source of renewable energy by itself can be a costly enterprise, unaffordable to many. Systems of grouping and sharing, however, proved to offer more viable alternatives. This can occur at a local level, a grouping of houses, or at a larger level, like a district, a city or at a national level.

3.1 Design strategies

The scope of designing an energy efficient dwelling is reducing its energy consumption rates and accessing renewable sources of energy while keeping the cost of construction and use sufficiently low. It has been found that the most impact on the investment and on the return of investment is achieved by passive measures, such as orientation, form, layout and façade design [31]. These are the measures which are usually taken in the design phase of the building, where the context (climate and orientation) is taken into consideration. These initial decisions can have an impact on the investment cost which can be as high as 30% [14].

Achieving an nZEB standard requires however that a building adheres to a specific value regarding energy consumption. This means that a traditional design approach, involving only the architect and the client in the initial phases of design can be flawed, since the decisions made in these early phases rely mostly on estimates [14]. The rest of the specialists usually appear in later stages only, which can change the design and induce increased costs. By contrast, a “Building Performance-Based Contract” [14] could ensure that all involved parties are focused on the actual energy performance of the building from the beginning. It also means that a multidisciplinary team involving all specialists (including cost evaluators) is assembled at the beginning of the design process. Also, there are two new design stages which can be added: predesign and recommissioning [14], which are aimed at ensuring that the final building behaves as expected. Predesign is a stage where initial data is collected and processed, the goals are defined and the initial decisions regarding orientation, shape, inner layout and construction method are taken. This is the stage where the budget is set and the resources are allotted. Being a multidisciplinary team, distributing the resources and setting the energy consumption goals can be made early and with a high degree of accuracy. Then there is the recommissioning phase which ensures that the building works as projected and that the inhabitant uses it properly, achieved through a post-occupancy monitoring and feedback process.
3.2 The impact of user behaviour on energy efficiency – energy culture

During the lifetime of a dwelling there is often this discrepancy between the projected energy use and the actual one. This performance gap is caused by flaws which can be found in the design process, during the construction and as a result of the use of the dwelling [14]. One study found that the impact of user behaviour on the energy performance of the dwelling is significantly higher on nZEB buildings than on traditional ones [24]. This means that due to their low-energy design these buildings react faster and better to a proper use than a traditional one. It has been shown that the way a dwelling is used can affect its overall energy performance, with differences of up to 30% between similar dwellings, inhabited by different people, with a potential to save up to 28% of energy used [25]. Setting the thermostat too high, overusing the thermal plant or the ventilation system are some of the most important factors which affect the performance gap [24].

Educating the user to help the dwelling perform better is an issue that can be achieved on two levels. Firstly, on a localised level, there is the recommissioning phase of the design process proposed in the previous section. It is a stage where the new inhabitant is informed regarding the dwelling’s systems and its overall functions and a period of monitoring and adjustments of its systems which can last for long periods of time [14]. This stage helps reduce the performance gap by adjusting various components of the dwelling, but also by informing the user.

After the recommissioning phase is over, a continuous interaction between user and dwelling can further assure that the performance gap is kept at a minimum. Systems which provide real-time feedback on energy use have been known to improve the energy footprint by helping the inhabitant adjust its behaviour to be more energy-conscious and to use the various systems in a more efficient manner [14].

Thus far the discussion referred to the actual dwelling and its inhabitant. There is however a larger perspective. Known as energy culture, this is something that has been researched since the 70’s, analysing various fields, from macroeconomics to sociology, in order to ascertain what impact the human behaviour has on energy consumption and pollution. For example, the International Energy Agency (IEA) speculated that a more energy-conscious behaviour could contribute to up to 50% of the required drop in CO₂ emissions by 2030 [26]. Human habits are hard to break, so this kind of an endeavour has to involve larger entities, such as state agencies or NGO’s using various means, from general information strategies to financial stimuli [27].

There is an obvious human component in the discussion of energy efficient buildings, with a significant impact on the energy consumption. A proper strategy should take this into account, covering the larger population, but also the individual inhabitant.

3.3 Site orientation and inner layout

The first choice when building is finding the proper spot. This decision takes several factors into account, such as maximising the green space, resolving intimacy, capturing a beautiful view or catching as much sun as possible. Regarding the thermal comfort, the layout tries to ensure that the important rooms are warm during the winter and cool during the summer. Proper orientation is actually something that builders did since immemorial ages, proven by the vast number of examples of traditional architecture all over the world. Adapted to the specific climate, some dwellings favoured cooling (warm regions), while others favoured warming (cold regions) and developed concepts which are still used today. Romania is one of the climates where both warming and cooling is necessary.
Properly orienting a building has been found to have a significant impact on its overall energy profile [28]. Optimum orientation is however something that is difficult today. Human settlements have evolved usually based on criteria that didn’t include energy efficiency. Over time, growing population meant higher density and modern settlements began to feel the lack of space. New regulations were introduced, new types of buildings were developed, most notable the collective dwellings, plots became narrower and with odd configurations. Orientation is thus a significant new condition that can be incompatible to the principles of modern human settlements. Addressing this issue directly may prove impossible in the near future, although examples of newly built settlements with these factors in mind do exist. Yet they are rare and localised and with a high degree of experimentation.

Architects learned however to address these issues by adapting instead the inner layout of the house. Massing the main rooms towards the more sun-exposed sides while blocking the shaded ones with annex spaces is one method. Additionally, there is the old principle of the buffer-spaces, something which is widely used in traditional architecture in many parts of the world. By interposing liveable or annex spaces between the outside (whether the sunny part or the shaded part of the dwelling) and the inside, where the main rooms are located helps regulate the thermal comfort and can greatly contribute to the energy efficiency of the dwelling. A study found that in comparison to a similar dwelling in terms of size, shape and height, the energy savings ranged from 5% (the pessimistic model) to 20% (the optimistic model) when properly using buffer-spaces and a proper inner layout [29].

Then there is natural ventilation which is directly linked to the inner layout and the orientation of the building which also adds to a low use of energy and also the whole range of devices and measures which improve on these basic principles: the use of vegetation, eaves, sun-blocking devices, systems of passively storing thermal energy like the “Trombe wall” etc.

3.4 Flexibility of the dwelling

The inner layout of the building and its overall principles is a means to address another issue which contributes to the energy use. One of the issues which became apparent when the Romanian case was analysed was a tendency of the dwellings to be overcrowded or underused. The capacity of a dwelling to adapt over time to the changes in the household is something that is increasingly important in the current context. Space has become more valuable and buildings more complex, so that maintenance and expenses increased. Especially acute is the case of the owned dwellings, where the household is directly responsible to these factors. In case of the energy efficient dwellings, they tend to be customised and thus highly rigid in regard to the inhabitant’s dynamics [14]. Yet, as it has been shown, failing to adapt can lead to an overburden of the household’s finances or to an overuse of its energy requirements.

A possible solution to these problems is a “loose-fit” approach [30]. This means analysing possible scenarios of the future use and with several inhabiting types in mind in the initial phases of the design. This process was actually used in Romania when the types of apartments for the collective dwellings built in the communist era were designed, although in a very limited way. Similar approaches were employed in many national dwelling programs in different countries. Certain types of inner layouts can be flexible enough to adapt to various scenarios, by using a partitioning system that is independent of the structure and that can be easily modified or by using rooms with sufficiently great surface so that they can accommodate many different uses. Also, there is the possibility to build only the essential part of the dwelling (the essential rooms and annexes), letting the future inhabitants expand or contract in accordance to their needs.
Flexibility is something that has to be taken into consideration when speaking about energy efficient dwellings and should be a subject of a more involved research.

3.5 Using the context

In Romania there is a tendency to use construction methods indiscriminately, unconcerned with local opportunities. Limited types of building techniques are used, both in a rural setting and an urban one, with the urban one usually serving as a model. This means that locally available materials are often disregarded and local workforce as well. As a result, materials are being transported from distant areas, builders also move over great distances, local knowledge diminishes and traditional material suppliers reorient themselves or disappear. All this adds to the cost.

In the predesign phase there is a stage where local materials are researched and proper building methods are evaluated in order to achieve the best outcome regarding initial investment and building behaviour. It is a strategy which is often used in self-built projects which are inherently constrained by these decisions. Encouraging the architects and builders to reorient themselves to the local available means and materials could potentially stimulate local businesses and know-how. Also, it could press for a stronger focus towards old techniques which stood the test of time and also towards new developments in materials and building methods.

3.6 Grouping and sharing

A strategy to achieve an energy efficient dwelling inevitably has to take into account the sources of energy. Accessing this energy is one of the more important aspects when designing such a building. The availability of several technologies has increased in recent years, demonstrated by the growing interest in using them in the residential sector. In a study on 17 countries in Europe, including Romania, it has been found that heat pumps are the most coveted for heating and photovoltaic panels for electric energy [24]. This means that, overall, there is a potential to supply the dwellings with energy from renewable sources.

In a context where energy poverty is high, reducing the ability of the households to access the energy infrastructure, and where household expenses are stretched, actually using such systems, albeit desired, can prove to be difficult. Again, there is also the problem of understanding them, using them and ensuring their proper maintenance. The budget is in most cases insufficient to hire a specialist. Forcing an energy efficiency standard on a singular household, as is the tendency, is in most cases unrealistic.

In these cases, sharing the financial burden can offer a solution. Using the plot's limits as a reference, there can be several situations: energy which is produced inside the building, energy which is produced inside the plot, energy which is produced outside of the plot, but with equipment which is owned and energy which is produced outside of the plot by the national grid [31]. This concentric system proposed by this study means that sometimes adjacent dwellings can begin to share these energy sources and the required equipment. Sharing can be among several dwellings, at the level of a small settlement, or at the level of the entire city. This system, sufficiently expanded, can help compensate different weak links, for example the energy consumed by less energy efficient dwellings can be distributed to others, more efficient dwellings, or spikes in the consumption of one dwelling can be absorbed by others, so the whole system can meet the energy efficiency requirements, rather than a singular building [31]. It is a method of distributing the burden so that the impact on single entities is reduced. Collective dwellings in Romania already use a similar system by their very nature. Heating is centralised, the building envelope is maintained with the collective funds of the homeowner.
A step further, sharing these responsibilities can be also externalised. There are already businesses which are specialised in building and maintaining solar farms or large heat pumps which can provide the necessary energy for a group of dwellings. A rent system is employed and sometimes also an adaptable system of bonuses which lowers the cost of monthly energy expenses when there is high input in the net or when, after adjusting their daily energy use patterns, households achieve certain efficiency goals.

What is interesting is that such a system, applied to a context like in Romania, should not impede on the established tradition of owning a dwelling. At the same time, it helps reduce the burden on the national grid which is presently struggling to keep up with the energy demand.

A law from 2005 specified cooperation as a legal way of building, which should reduce costs and share maintenance costs, however there is no implementation guide and as a result the banks do not recognise it as a form of association [11]. What is called Housing Cooperatives, which could be a very good solution, is yet to be implemented in Romania.

4 Conclusions

Trying to understand the Romanian context and its specific dynamic actually exposes the first problem: the lack of data. Detailed and perpetual analysis of a situation is the first step of a larger strategy. Energy efficient dwellings have a specific set of characteristics and therefore depend on a specific area of knowledge. Devising a national strategy designed to implement standards of energy efficiency should be backed-up by a system of collecting data relevant to this aim.

This leads to a second problem, that the guides for implementing the nZEB standard in Romania keep focusing on the individual house owner [3]. This means that the whole concern of a potential national strategy is concentrated on detail and loses focus of the overall picture, which, due to the lack of available data, is insufficiently understood. A specific context needs to be created in order to help develop a new energy efficient dwelling culture. In order to create it or to support its development means setting a framework first.

A third problem is that the house owner is overburdened with all these norms and in a context like the Romanian one this is unrealistic. The individual house owner cannot single-handedly face all the consequences involved when investing in an energy efficient dwelling. Here sharing and grouping could be an answer, as it was shown. However, these forms of association are still to be regulated in Romania.

A fourth problem which has to be addressed is the level of knowledge the public has about this new way of thinking, reorienting the energy culture towards a more energy conscious way of life. Besides the financial burden, the dweller has to understand how such buildings work and how to maintain them. On top of that, he needs to understand the benefits of owning such a dwelling, for him mostly, and for the environment as well. This new mind-set, invest more and save later, is something that is in contradiction with an established way of thinking. In order to determine him to take this road, there is a need of ample information campaigns done at all levels, by certain state entities and civil organisations as well. At the same time, as has been shown before, a constant monitoring of the house and its energy use based on behaviour patterns can insure an improvement of the performance gap and a constant level of energy efficiency.

There could be also a positive side-effect of the high ownership degree of dwellings in Romania. A house owner is more emotionally invested in his dwelling and therefore more open to ways of increasing its quality, of maintaining it properly and of upgrading it when necessary, so it is not a mere business, it is an existential matter. His home is something
which is perceived as multigenerational, built to last longer. With a high percentage of house owners, Romania could possibly experience an accelerated transition towards a more energy efficient dwelling culture. This, however, is something that has to be studied in detail.

Changing the mindset of the dweller is also an important step done towards laying the groundwork for a specific market which is oriented towards these goals, in other words, setting up the demand. Once this is accomplished, lawmakers, industry, construction market, civil organisations etc. become involved. After the demand is set, finer points can be addressed, such as the specific strategies of designing an energy efficient dwelling regarding orientation, inner layout, materials used etc.

And this is the fifth problem which has to be taken into consideration. Laws and norms have to be devised in order to guide the decisions of the designers better. Here, a strategy which emphasises passive measures first and explicitly setting them as basis for a future construction could be more adequate. This means, of course, that these guiding lines should be context sensitive. Romania has many distinct areas with their own climate characteristics, topography, natural resources, demographics and cultures. It is improbable that a general rulebook can address all these situations. General principles have to be tailored to them. This again means collecting data and finding the strong points and opportunities on which to build.

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