# Energy-efficient home design: Learning from the past

**Andra Jacob LARIONESCU**
*Spiru Haret University, Romania*

usharh_jacob.andra@spiruharet.ro

**Michael MONTANARI**
*Parma University, Italy*

montanarimichael@yahoo.it

**Abstract**:

*The paper is focusing on Energy-Efficient Home Design or how to design a house in order to reduce energy consumption. We will use the vernacular architecture as an example for good energy-efficient home design, the past experience serving as a base for future housing development. Green Architecture is the theme that surrounds our approach because it tries to articulate the past experience and innovative technology, considering different design features, such as: size of the house, insulation, ventilation, heating and cooling equipment, solar energy systems and other parameters which serve to obtain environment certification (e.g. Leed, Itaca, Breeam, CasaClima). Various examples of vernacular architecture in Italy and Romania will lead us to consider the importance of the climate, site, house orientation and shape and local materials in designing an energy-efficient house. Finally, new green house design should be seen as an investment in building a better community rather than a cost.*

**Keywords:** *green house, green architecture, vernacular architecture, energy efficiency, innovative technology, recycled materials, reused materials.*

## 1. Introduction

Green Architecture is a key component of the 21st century building design, having far-reaching implications for the future well-being of people in different parts of the world. New structures such as schools, museums and skyscrapers are already designed on the basis of this new philosophy. Today we are more than 7 billion people in the world, situation that has a huge impact on the exploitation of the the Earth's natural resources. Our paper is focusing on "energy-efficient house

design" or how to promote a sustainable management of natural resources.The high number of dwellings cannot be ignored as all these are causing air pollution and considerable amount of energy consumption. Green Architecture could be the solution to stop this constant environmental degradation.

We will use some case study of traditional vernacular architecture as an example for good energy-efficient home design, the past experience serving as a base for future "green" housing development. We will explore the main features that allow an energy-efficient home design and how to benefit from innovative concepts like passive house design. Local materials, house form and orientation are a key to energy-efficient home design.

## 2. A brief history of the green architecture

After World War II, the suburban sprawl was on the rise in the United States. This event caused a strong increase in carbon dioxide emissions into the atmosphere, known as "Greenhouse Effects". This process led to the birth of firsts eco-activists, who decided to move in rural communes in order to live in less polluted localities. They built different types of houses such as tent-like structures and geodesic domes to low the impact on the environment. This growing "green" movement was aiming at reducing the pollution. Influential pioneers, such as the American philosopher Lewis Mumford, the Scottish landscape architect Ian McHarg and the British scientist James Lovelock, have greatly contributed to enhance this green design concept.

In 1960, environmentalists, green architects and ecologists were slowly modifying the meaning of living within the society of the United States. Nevertheless, it was still not enough since the rest of population continued to ignore the principles of environmental conservation.

However, the first "Earth Day" was celebrated in 1970. The event represents an early form of environmental protection, following the natural disaster of *Santa Barbara Oil Blowout* that happened in the previous year. The OPEC Oil crisis in 1973 caused also a significant increase in oil prices in the United States. As a consequence, the American government was looking for alternative solutions and new energy sources and consequently began to invest in solar, water, wind and geothermal energy as sources of power.

From mid-1980s and early 1990s, environmental advocacy groups continued their efforts in order to sustain the development of new building techniques. Architects and builders worked hardly to establish the right standards for green design. In 1993, the U.S. Green Building Council (USGBC) formulated the *Leadership in Energy and Environmental Design* (LEED). These standards include specific parameters, providing additional guidance to designers and builders to achieve sustainable structures. According to the newest version (v4), the main points of LEED cover the following areas:

- Integrative thinking
- Energy
- Water

- Waste
- Materials
- Location & transportation
- Sustainable sites
- Health and human experience
- Regional impacts
- Innovation
- Global, regional, local.

Although LEED is one of the most known environmental certificates, it's certainly not the longest. In 1990, the Building Research Establishment (BRE) of England published BREEAM (Building Research Establishment Environment Assessment Method) in order to certify the sustainability of future buildings. Indeed, until today, BREEAM has certified more than 250.000 buildings, being used around the world in more than 50 countries. Others certifications were published later, such as ITACA in Italy and CASBEE in Japan, both formulated in 2004.

### 3. Climate: the fundamental starting point for Green Architecture

Climate is a key factor when designing a green house, as architecture and climate are strongly linked, the second influencing the size and configuration of the house, the building materials, the site.

How many climate zones should Green Architects consider when designing a house?

According to the Köppen-Geiger Climate Classification, our world is divided in five main climate zones: (A) Tropical, (B) Dry, (C) Temperate, (D) Continental and (E) Polar. However, the Köppen-Geiger system has three tiers, each zone being split into several sub-climate zones, according to the precipitation type. For example the Tropical zone shows four types of precipitations, from rainforest climate (Af), with average precipitations every month, to Savanna dry climate (As) with little rainy seasons. Moreover a third letter is assigned to them to indicate temperature, that can also change (from cold to hot).

Thus, climate shapes the human life, serving as a context for the expression and manifestation of different cultures. Every culture had to adopt various building systems in order to protect the population from cold winters or warm summers.

Depending on the building site, one can discover different types of vernacular buildings. These structures represent a fundamental part of our history since countries'past populations did not use the innovative materials and the technology we have today. Modern insulation materials, air-conditioners or just reinforced glass for windows were unknown in the past, therefore households had to build their own dwellings with natural local materials. This aspect is central to our approach, as it tries to articulate the past experience and innovative “green” technology. Although there are a lot of new devices that help us reduce the energy consumption in a house, we should take advantage of “old-fashioned” methods and techniques of our

predecessors. For instance, different examples of vernacular architecture in Italy and Romania have been identified to serve as a base for future energy-efficient home design. In all these examples, we show the techniques that were used in order to protect the household against adverse atmospheric conditions.

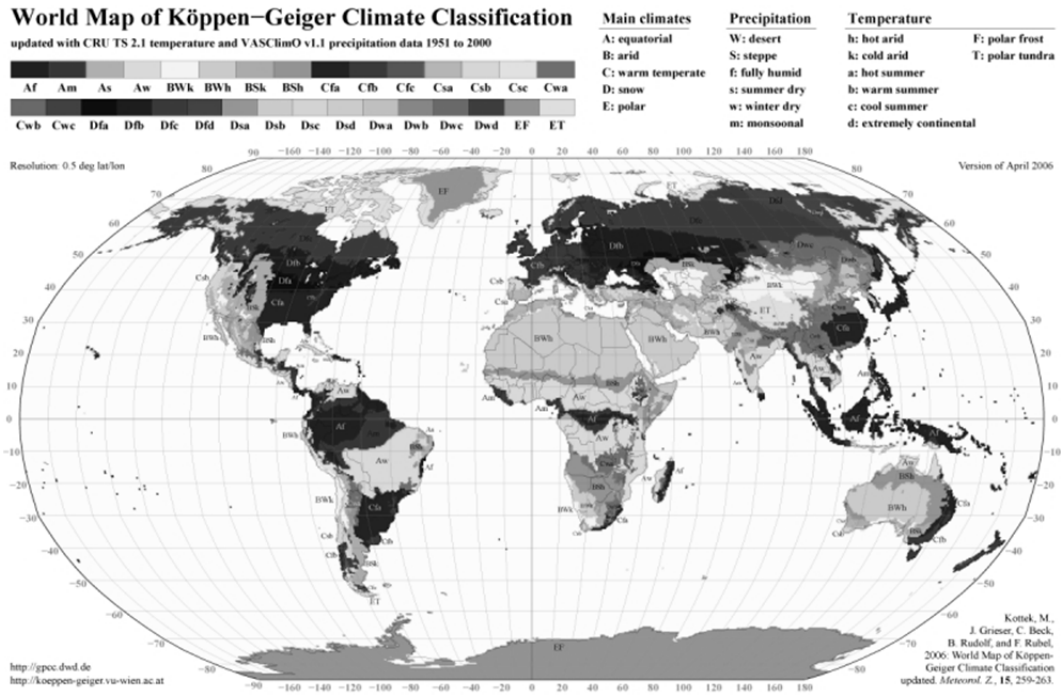


**Figure 1.** Köppen-Geiger Climate Classification.
*Köppen-Geiger climate classification: http://koeppen-geigr.vu-wien.ac.at/present.htm*

## 4. Traditional-vernacular Italian Architecture

### *4.1 Dammuso*

It was created in the 10th century A.D. and developed up until the 17th century.

There were two different construction methods, one using the local volcanic stone, while the other building a characteristic vaulted roof. In this way a very solid living space is built, making it durable, fire resistant and well adapted to the island's climate. The exceptionally wide walls are necessary to support the domes, which are finished with a mixture of red tuff and plaster forming a hard, waterproof surface. The particular shape of the curved roofs has been conceived above all for the drainage and collection of rain water. The water is stored into the cisterns situated in close proximity to the “Dammuso”.

The thick walls of these houses isolate them, keeping the rooms cool in the summer and warm in the winter. As the Dammusi are built out of the natural stone found on the island, they blend in very well with the surrounding landscape.

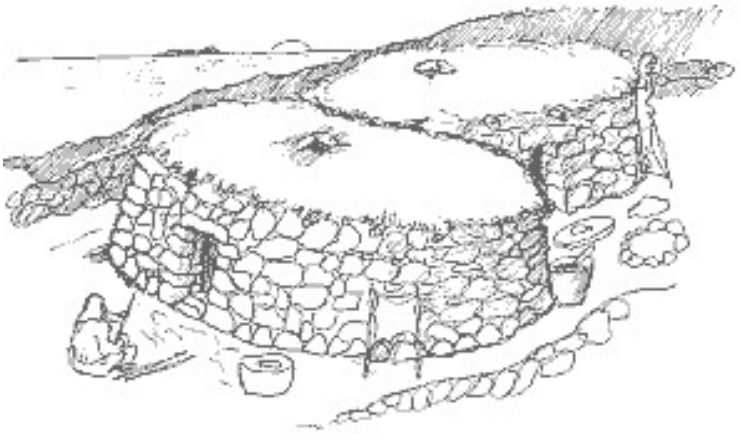

**Figure 2.** Dammuso of Pantelleria.
*Giacomo Patanè: http://www.pantelleria.com/english/pantelleria/dammuso.asp*

*4.2. The Trulli of Alberobello*

The Trulli are cone-roofed houses of Alberobello, one of the 53 UNESCO World Heritage Sites in Italy.

This type of shelter has a circular, limestone masonry base, grafted onto the underlying natural rock, made of the same substance.

The interior space is organised around a central room showing the modularity of Trulli.

The walls' thickness, as well as the scarcity of windows, ensures an ideal thermic equilibrium: warmth in winter and cool temperatures in summer.

The roof is composed of a pseudo-dome made of horizontal limestone slabs, positioned in series of diminishing, concentric circles called "*chianche*" (interior), and "*chiancarelle*" (exterior).

The keystone is an important structural element that supports a large protruding frame which transfers rainwater from the roof into the cisterns situated in the basement.

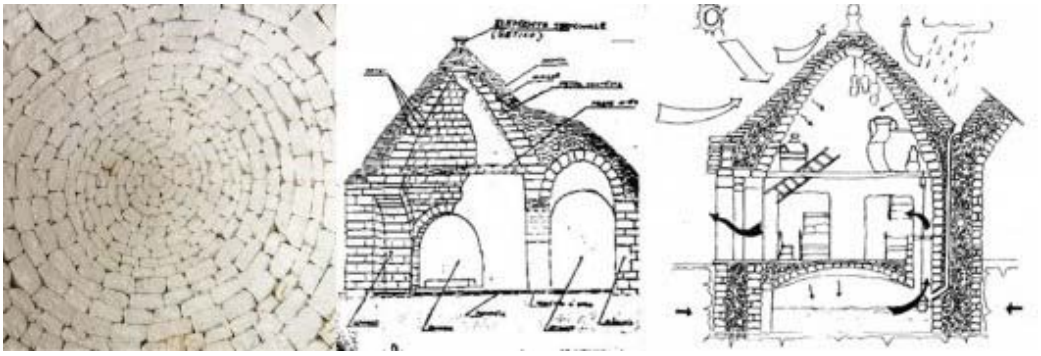

**Figure 3.** Trulli of Alberbello.
*Ana Asensio: https://theaaaamagazine.com*

*4.3. The Cuiles*

The cuiles are small shelters of Sardinia used by past shepherds during their long travels.

The Italian translate of "Cuile" is "Ovile", that means a fold used for keeping sheep. Their form remind us of a hut one. It is especially possible to find them into the most natural environments of the Island, for example along the trail of Supramonte. The Cuiles are wood and stone structures with about 4 m in height.

They were built with cone-shaped juniper trunks, a local resistant wood that ensures no permeability within the structure, supported by a circular calcareous-stone wall.

A "hat", called "su cugumale", is placed on the top of the hut in order to protect the indoor space from rain and snow. Within there was just enough space to host the shelter and the fire, which works in order to heat both the interior environment and keep hot the dairy cheese.

Branches of Frasche Trees were used as covering for the small shelter keeping the warmth inside.

The Cuiles are a typical example of traditional- vernacular architecture that show the whole respect toward the environment through the simple use of local raw materials.

**Figure 4.** The Cuiles of Sardinia.
*Cala Gonone:* https://www.calagonone.eu/last-news/curiosita/912-cuiles-del-supramonte

*4.4. The Walser House*

The Walser houses in Piedmont, dated from the late 16th to mid 19th centuries, and are perhaps the earliest examples of vernacular architecture in this form. Their main characteristics are:

- a wooden wall bearing system with a regular grid in plan and in section;
- dry-stone walls for the ground floor that support the upper floors;
- a wooden pitched roof

The main façade faced south in order to obtain the maximum solar radiation and these houses were all clustered to better use the terrain.

These constructions usually present a square plan on three storeys, the ground floor housing the stable and a common room. The bedrooms were on the first floor, so that the below warmth could heat them; while the top floor was used to store the beech leaves.

The stone walls are thick (around 60 centimetres) in order to keep the heat inside the house and to support the upper wooden structure. The soapstone oven, on the ground floor, heated the interior space where humans and animals lived together (separated by a low partition wall). There wasn't any chimney to expel the smoke. The smoke was removed through natural ventilation using the windows and the main door, which was divided in two parts. The highest part was open to remove the fumes from the room, while the lowest one was closed in order to keep the house warm.

The external wooden walls and beech trunks were joined by dried moss that worked as a thermic insulation.

Today the Walser Houses are subject to different restoration and reconstruction work in order to preserve this type of Italian vernacular home.

**Figure 5.** Walser House.
*Unité des Communes valdotaines Walser:* http://www.cm-walser.vda.it/Walser?Casa

### *4.5. Sassi of Matera*

This type of dwelling is perhaps the oldest type of vernacular architecture in Italy and a good example of environmental building. At the beginning, the residents used this caves as shelters, to protect themselves from adverse atmospheric conditions, then they turned them into natural dwellings. Sassi of Matera dwellings were objects to a continuous shift for over nine millennia to meet the changing

human needs and living practices of the time. Therefore they passed from simple natural caves to real dwellings with complicated forms and shapes. These mutations express a typical human adaptation to the natural environment. Indeed, on one hand the inhabitants skilfully exploited the local climate and land's temperature in order to keep the fresh air inside the shelters, and on the other hand they built new structures using the same stone, pulled out of the rocky ground. The natural slope of the land was used to drain away the rainwater and to collect it into cisterns.

The Sassi of Matera was classified as a UNESCO World Heritage site in 1993, leading to different conservation actions aimed at strengthening the local identity through preservation and restoration work.

These small and narrow shelters of maximum 30 square meters housed large households. The light came from up, like in the north African shelters, and the interior temperature is constant (around 15° C) due to the thermic mass of the tuff rock.

Matera has is a candidate for the future European Capital of Culture in 2019.

**Figure 6.** Sassi of Matera.
*Atlas Obscura: https://www.atlasobscura.com/places/sassi-di-matera*

### 5. Traditional-vernacular Romanian architecture: the village of Marginea

In Marginea, a village in Bukovina, the orientation of the dwelling and the protection against the prevailing winds was very important: the main facade with the entrance faced southwards, avoiding the northeast winds, particularly strong during the winter.

**Figure 7.** The main facade with the entrance (Author personal photo).

The peasant house comprised an entrance hall, a representative room on the eastern façade, a family room on the western façade and a storage room to the north, in the back of the house. The house relation to the street was less important and we may find different Romanian houses that turn their back on the street if the latter faces the geographical north. Also, the northern slope of the roof goes down unto the ground (or near the ground), the north facade having no windows. The house had also a porch on one or three facades to protect them against the rain.

**Figure 8.** The northern slope of the roof goes down unto the ground (Author personal photo).

Another feature of the peasant house in the village of Marginea was the selective heating of the rooms, depending on the seasons, due to the scarcity of financial resources. Thus, the house had one or two rooms without a source of heat (stove), these rooms were either not used or used during the summer. Sometimes, a single stove was used to heat two rooms: "The heat of the fire on which food is cooked [on a metal plate in the kitchen] passes into the next room where a blind stove is located, crosses it and comes out in the kitchen, then go into the attic" (Stahl, 1978: 117).

**Figure 9.** Multifunctional room: kitchen with stove (Author personal photo).

Thus, «… the stoves are built such as to form the wall between two rooms. This way, with a single fire the food is prepared and two rooms are heated» (Stahl, 1968:57). The steep roof with four slopes, covered with shingle had wide eaves. The smoke from the stove could exit through two or three openings on the southern slope of the roof.

**Figure 10.** Exits on the southern slope of the roof (Author personal photo).

There was no chimney, the smoke being used to heat the attic, in order to preserve the meat (the meat was stored in the attic) and to protect the shingles of the roof.

The practice "To lit only one fire at a time" (Stahl, 1978: 117) was transferred to the new houses by migrants as they chose to selectively heat the rooms during the winter. This "debrouillard" way of life is also evident in the household layout: they used two kitchens, a winter kitchen, inside the main house (functioning both as sleeping and eating area) and a summer kitchen situated in the outbuildings. In the winter kitchen, the large stove with its iron hob was used only during the winter, while during the summer the food was cooked and prepared in a separate summer kitchen, on a gas cooker, or even in the yard, on a small tin hob.

The wooden facades were plastered with natural materials, a mixture of clay and straw. This layer was applied on a lattice support, and then coated with lime.

In some cases, the peasants chose to reuse the well preserved logs of old houses or even purchase an entire house that was dismantled and then assembled on its new site. In still other situations, old brick, wood or iron was reused to build walls, roof structures, doors or even entire houses (weekend houses). Nowadays some migrants reuse (or restore) the furniture items or appliances that Italians no longer need.

## 6. Modern "green" houses

Finally, we will compare the previous examples of vernacular houses with the new, contemporary "green" houses. The latter need more facilities, such as heating and cooling systems, in order to meet the new living standards. Architect's task is to minimize the energy consumption, using modern devices (e.g. photovoltaic and solar panels, controlled mechanical ventilation and triple-glazed windows) and appropriate design and site analysis. For example, a modern designing concept, like Passive House, can reduce both the energy consumption and the usage of relatively expensive energy sources.

Considering different parameters (e.g. climatic factors, building site, local materials, building orientation, alternative energy sources etc.) one achieve Nearly-Zero Energy Buildings (NZEB).

### *6.1. Seaweed House on Læsø: Vandkunsten Architects*

Læsø is a small island in Denmark with around two billion residents.Here we find a small summer house that interprets the old traditional seaweed house. This modern house is covered with "eelgrass" that works like thermal insulation for the roof and facade. The house is a combination between Green Architecture and environmental building. In fact during the Middle Ages there was a complete lack of wood due to the huge amount of furnaces built for the salt production. Therefore the inhabitants learnt to use available, local materials, such as seaweed and driftwood. This modern, Danish Architect's project combine the past experience with the modern techniques of Green Architecture. Eelgrass is fireproof, non toxic and having

a lifetime of over 150 years. Moreover, the modest size of the project reduced the cost of construction materials.

*"Life cycle analysis shows that the Modern Seaweed House bind CO2 in the order corresponding to CO2 emissions by ten years of use. This is a noticeable reduction in the collected energy use compared to most traditional buildings. The question is, what happens if the building is torn down and the materials incinerated – will then the entire CO2 deposit be exposed out into the atmosphere? Yes, but in that case the CO2 binding materials will replace other kinds of fuel and maintain a positive effect on the climate."*[1]

**Figure 11.** Modern Seaweed House.
*Vandkunsten Architects: vandkunsten.com*

*6.2. Earth-ship*

Earth-ship is a type of passive solar house built with recycled materials and earth. This ultra-sustainable home was developed for the first time in New Mexico by Mike Reynolds Architect. After graduating in 1969, he began working on this project in order to achieve an extremely energy efficient house. The structure is composed of recycled tires, aluminium cans and bottles packed with dirt, then plastered over with mud. Earth-ship house faces the South in order to adsorb the maximum sunlight. The house is partially buried into the ground to keep it cool in summer and the warm in winter. The curved tin roof allows the rainwater to drain and the snow to melt and then to collect the water inside the house. The water comes filtered and is used in bathroom, then recycled to water the garden.

Earth-ships structures have a natural ventilation system based on convection. Photovoltaic panels and wind-turbines generate DC electricity that is stored in deep-cycle batteries.

[1] Vandkunsten Architects, Architectural Seaweed, Modern Seaweed House, Læsø Island, 2012–2013.

**Figure 12**. Earth-ship.
*Khushboo Vyass: https://www.arch2o.com/earthships-michael-reynolds/*

## References


Adriana De Angelis (2015), *Le dimore delle tradizioni sarde*, Mediterraneaonline. Eu.
Carmen Granata (2015-2016), *Abitazioni tipiche*, Blog.casano.
Davo H. (2015), *Low Energy, passive and zero-energy house*s, Our Energy.
Elena Casolino (2012), *Architettura spontanea, un viaggio tra gli edifici piú alti originali al mondo*, Architetturaecosostenibile.
Energy. Gov. *Energy Efficient Home Design.*
Federica Garofalo. *Cos'é l'architettura ecosostenibile, definizione, principi e progetti famosi,* Lifegate.
Gabriele Crepaz (2015), *I protettori dei Masi*, Storie da vivere, Sudtirol.
Giacomo Patané (2016), *Dammuso. The typical construction of Pantelleria*, Pantelleria.com.
Gian Basilio Nieddu (2015), *Cuiles, da architettura rurale a nuova risorsa del turismo sotenibile in Sardegna,* Greenews.
Giuseppe Pagano, Guarniero Daniel (1936), *Architettura rurale italiana, Quaderni della triennale*, Milano.
Ian L. McHarg (1995), *Design with Nature*.
James Wines, *Green Architectur*e, (2008). In Philip Jodido (ed). Encyclopedia Britannica.
Kushboo Vyas (2016), *Earthships. Michael Reynolds*, ARCH20.
Lewis Mumford (1974), *Pentagon of Power: The myth of the Machine,* Vol. II.
Lorenzo Bisbano (2017), *Le case con I tetti di alghe nell'architettura vernaculare e moderna*, Architetturaecosostenibile.

Michelle Honeyager (2015), *Green Architecture, Past, Present and Future,* Recycle Nation.
Mike Reynolds, *Efficient Home Design*, Ecohome.
Renewable Energy Vermont (2015). *Technologies.*
STAHL, H. H., STAHL P. H. (1968) Civilizatia vechilor sate romanesti.
Stahl, Paul H. (1978) *La maisnie (gospodăria) du paysan roumain*, Freiburg: Biblioteca Română.