HUNGARY

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1 OVERVIEW OF THE REGION

Characteristics of the Region
The region of Vasvár presented in this case study is located in Vas County in the Western part of the country, which is one of the 19 counties of Hungary. The region of Vasvár is one of the 7 regions of Vas County and is considered to be a medium-sized region (see *Figure 1*) (1).

Figure 1 – Illustration of the Vasvár region as a part of Vas County, which is located in west part of Hungary

Hungary covers an area of 93,000 km^2 and has a population of approximately ten million inhabitants. Vas County has a territory of 3,336 km^2 and it has a population of 261,569 inhabitants (21). Its centre is Szombathely. The Vasvár region is part of Vas County and its territory is 474 km^2. It has a population of 14,395 (TEIR, 2010) inhabitants. With 36 inhabitants/km^2, the population density is the lowest in the county. Its centre is Vasvár, which is an old historic town. Although initially Vasvár used to be the center of the whole county, nowadays it is the smallest town in Vas County but it has kept its leading cultural role. Other towns in Vas County include Sárvár, Körmend, Celldömölk, Kőszeg and Szentgotthárd.

The employment rate of the region is good (60%) in comparison to other regions of Hungary. While the unemployment rate in the Eastern part of the country exceeds 20 %, it is below 5% in Vasvár region. GDP per capita in Hungary reaches €10,168. GDP in the Western regions is higher than in the Eastern regions, similarly to the employment rate.

The reason this region has been selected is that there are a large number of adobe houses. We have dealt with the renovation of these houses and its impacts on the environment. Adobe is a natural building material made from sand, clay, water, and some kind of fibrous orrganic material (branches, straw, and/or manure), which the builders shape into bricks (using frames) and dry out in the sun.

The structure made from these materials is very solid and long-lasting. In Vasvár region this building method has a long history. The building technology is very similar to the technology of moulded wand and slide-jalousie reinforced concrete. The renovation of these houses is not only important from the perspective of the cultural heritage but also from the energy saving aspect as well. Instead of building new houses and demolishing the existing ones, renovating them can result in energy saving and reduced CO_2 emission. *Figure 2* presents the distribution of building materials within the building stock

Due to cheap, local raw materials and good physical properties (thermal and humidity balance effect) adobe architecture has become fashionable again. Houses have been built with this material mainly in Europe but adobe walled buildings (churches, research institutes, etc.) are common in Africa or Asia as well. The building technology using adobe walls is very diverse (17,18).

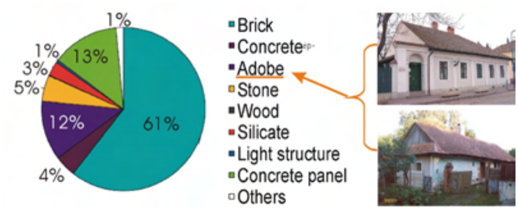

Figure 2 – Houses in Hungary according to the building material. A large number of the buildings are from adobe

At present, Szombathely is the administrative and economic centre of Vas County. In the past it used to be Vasvár, while nowadays, Vasvár is the smallest town in Vas County. The interrelation of the settlements can be investigated with the help of the measure of complexity. Hence we are going to examine the Vasvár region. We have already described our research in our earlier publications (26, 27). The results of our research can help us in the planning of sustainability. The sizes vs. sequence number graphs are showed in *Figure 3*.

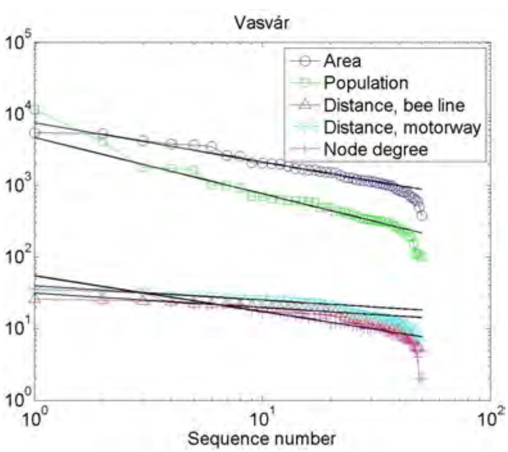

Figure 3 – The sizes vs. sequence number graphs for Vasvár regions. The meaning of the symbols are inserted in the figure

Area, population, distances in bee line and motorway, and node degree exponents are calculated for the region (2, 3). The exponents for Vasvár are also in sequence: -5.471x10-1, -7.852x10-1, -1.999x10-1, -1.989x10-1, -5.012x10-1, respectively.) You can clearly see that the steepnesses are nearly similar, thus the settlement structures are unified. Although Vasvár has lost its role as an economical centre, it has preserved its role as a cultural centre.

Energy demand and supply of the Region
The percentage of the energy demand in the region is in accordance with the national average (*Figure 4*). Hungary has more industrialised parts mainly around larger cities or in the Northern middle mountains. There are also agricultural areas where energy varies. The Vasvár region is closer to the average in this perspective. The pie chart below illustrates the percentage of the energy demand (4 – 9).

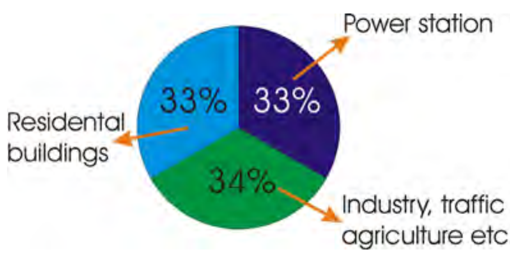

Figure 4 – Distribution of the primary energy demand among the main user sectors. The energy demand of the residential buildings is very important

The energy demand of residential buildings accounts for 33% of the total. This value depends on the quality and the type of the buildings. The structure of the settlements influences the type and also the quality of residential buildings. The comparison of the town vs. village ratio is shown in *Figure 5*.

Figure 5 – The structure of the settlements influences the type of residential buildings

2. CURRENT SITUATION: TARGETS RELATED TO ENERGY POLICY

Setting and meeting the targets related to energy policy is primarily based measures of CO_2 emissions. *Figure 6* illustrates the trend for CO_2 emissions changes from 1970 to 2010, including the breakdown for the main sources of emissions (6 – 9).

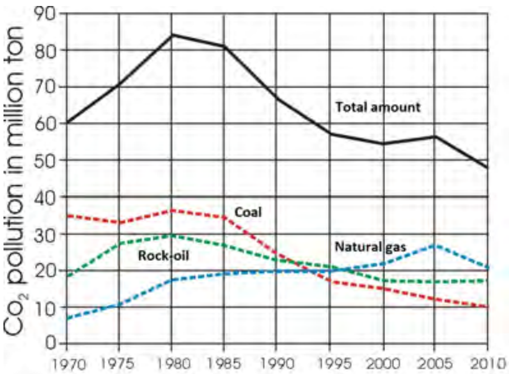

Figure 6 – CO_2 emissions of Hungary.

The black solid line shows the total amount of pollution. The dotted lines represent the contributions from different primary fuels. The red, green and blue lines represent coal, rock-oil, and natural-gas, respectively. CO_2 pollution was $48x10^6$ tons. 31% originated from the production of electricity and heat; 27% from traffic, transport; 21% from industrial source; 17% from communal sector; 13% from other sources. The data relates to all of Hungary but it applies to all the region as well. The utilisation of renewable energy sources is very low.

The major aim for the future is to use solar energy for water heating in a more efficient way in the region. In this region, the use of solar energy for heating purpose or electric energy is not yet widespread. This can be explained by the fact that the population of the region simply cannot afford it. The region is rich in forests, which are full of wood waste that can be used to operate machines run by biomass.

The main aims of the Hungarian energy policy include security of supply, sustainability and competitiveness. The priority of environmental issues and the adjustment to the aims of the EU are emphasised. In order to create a balanced structure of the energy resources, the proportion of domestic energy resources needs to be increased as much as possible. One of the keys to achieve technological development is supporting education and R&D in the field of energy in Hungary. (28, 29)

Other important objectives include reducing energy consumption per unit, increasing the proportion of energy gained from waste and supporting environmentally-friendly technologies. It is important to harmonise the Hungarian energy policy with climate policies. By funding the production of fuels made from renewable energy resources, the transport policy can also became more environmentally friendly. One must also take into consideration the importance of funds provided by the state and the EU so that we could achieve these goals. In the public sector it is also essential to increase environmental awareness by introducing environmental studies into the National Curriculum. By building awareness, it is possible that the population might start to reduce its energy consumption.

Other Regional targets, barriers and drivers
A guideline of the European Parliament and Council 2006/32/EK (ESD) imposes an energy efficiency action plan (NEEAP)* that each member country has to draw up. This action plan outlines all of the running and planned measures of energy efficiency, which will make it possible to reduce energy consumption in Hungary by ca. 10 % in the span of nine years between 2008-2016 (28, 29). The action plan is crucial to achieve the reduction of energy consumption by 20 % until 2020 imposed by the European Union. As a result it will also be possible to reduce the GHG emissions by 20 %. The action plan involves the following areas: the construction requirements of new buildings; the number of residential buildings; the number of communal buildings (especially buildings owned by the state and local councils); education; transportation; public transport; and technologies which can influence the volume of the energy demand. It is clear that residential buildings are of primary importance therefore our case study also reflects on this issue.

In the public sector the process includes keeping and controlling the energetic regulations of buildings and restricting gradually these regulations. Renewing the buildings of the public sector in view of energy efficiency is of absolute priority. It can demonstrate the state's commitment towards environmental issues, and it can make energy saving and efficiency campaigns and programs more credible. It can also lead to energy saving, more efficient budget management and more efficient leadership.

In the transport sector the following energy policies have been introduced: in order to reduce freight traffic, road tariffs have been imposed on freight vehicles, and the P+R system has been developed to encourage commuters to use public transport. In addition to a more sensible transport system, it is also important to create better transport ethics. A major advantage of this area is that it holds geothermal water at 78°C at 2,100 m below the ground surface. This geothermal water is used in district heating and in thermal baths. The utilised heat energy in 2010 was 13,386 GJ/year which from thermal water was 3,951 (GJ/year). The major aim for the future is to utilise more efficiently their available geothermal water resources (23).

3. CASE STUDY: SOME ASPECTS OF THE REGIONAL BUILDING STOCK

As the arguments above illustrate, one of the most important factors for energy demand in Hungary is the building stock (10 – 14). In the region that we have studied, the number of adobe houses is substantial. and they are also part of the cultural heritage. In this case study we will look at how it is possible to meet energy efficiency requirements while protecting the cultural heritage. Adobe houses are only known in certain parts of Europe. This is a traditional building method which fits in the local environment perfectly. Walls are contructed with hard composite materials, which made of local resources.

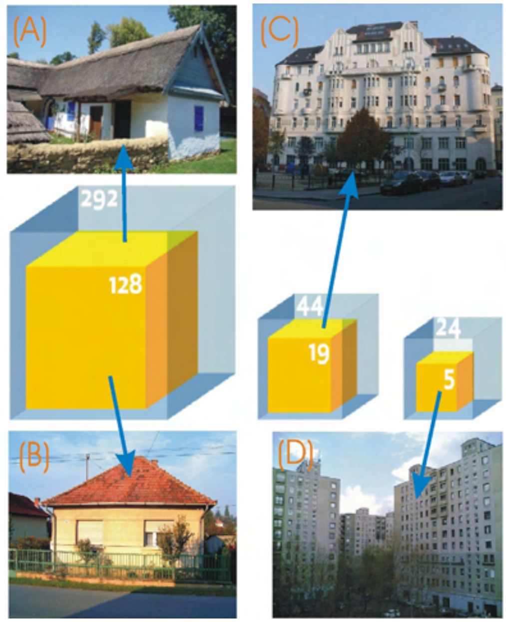

Figure 7 – Energy saving potential in the case of different types of buildings. (A) traditional cottage in a village, (B) a detached house in the suburbs of a city or in the country side, (C) in a block of flats of the city centre, (D) a block of flats mainly in suburbs built in the socialist era. The blue cubes represent the total primary energy consumption per year (in PJ), the yellow cubes represent the energy saving potential (in PJ)

Despite 73% of the European population living in towns (23 – 25), this value is is only 64% in Hungary. The energy demand for different building types is also different. In the region of our case study, the proportion of the rural population of villages is even higher and they live in adobe houses. Therefore the solution to this problem is a major architectural and energetic task.

In the *Figure 7* we illustrate the possible volume of energy saving comparing different types of buildings.

Buildings and houses in Hungary according to the building material is shown in *Figure 6*. Energy consumption and saving potential in the case of different building types are shown in *Figure 5*. There are two types of houses in a village. We can mention the village of Kám as a typical example in this region. The number of adobe houses in poorer villages (e.g. Csipkerek) is higher than in wealthier villages (e.g. Alsóújlak). One of the buildings is the traditional rural house (A) built from adobe or brick. The other one is a conventional detached house (B) built from a new type of brick. The third one is a traditional block of flats built from bricks (C). There are three types of the residential buildings in the Vasvár. The fourth one is a block of flats built from reinforced concrete (built in the socialist era). Houses built with adobe walls are very popular in the Hungarian vernacular architecture and are particularly characteristic in the region of our case study. A large number of buildings are built with this material.

Objectives and methods

The aim is to preserve houses built from adobe, representing Hungary's cultural heritage by renovating and making them environmentally friendly and comfortable. This can only be achieved if the people living in these houses do not consider them outdated and obsolete, so they will notbuild another house (15 – 17). In addition to technological aspects, cultural aspects – changes in the way of thinking – are also essential. In our investigation Life Cycle Assessment has an important role as well.

Long term focus

Sustainability has to be taken into account in the long term. However, preserving and renovating old houses and buildings is more important in the short term. Long term sustainability can be problematic as houses made of adobe walls need more care than brick walled houses. However using state of the art materials, one can make these houses modern, so that and additional care is not required. Preserving cultural heritage definitely supports long term solutions.

Discussions

It is possible to build houses with bricks dried in the sun but the sliding frame solution is also a possibility. The fleckered – plastered structure within the frame is also another possible solution. All of these three technologies used to be common in vernacular architecture in Hungary. Nowadays, only the first two solutions are mainly used. Stokers built with adobe walls are also very common. There are more types of adobe houses. The most common one is the adobe brick dried in the sun, which is used to build traditional brick walls. Another common wall is the wicker built on a wooden structure, which is covered with clay. We also mentioned in the introduction the technique of slided form-work similar to the monolitic reinforced concrete. This is the most common technique. Adobe wall architecture is excellent in the Hungarian climate because winters are cold and summers are hot. It is necessary to store the heat. Due to global warming summers are getting hotter, thus the heat storage capacity of newly built brick and lightweight houses is not needed. As a result, many air conditioners are installed in newly built houses. Well-insulated lightweight houses are appropriate in the North and in mountainous areas where the temperature does not exceed 20-25 oC in summer. Hungarian climate changed sensibly in the past 25 – 30 years. In summer, it is very common that temperatures rise above 35 oC. Earlier temperatures above 30 oC were unusual and were considered to be tremendously hot. Local people are not accustomed to the new warmer climate , thusthey use air conditioners more often. Unfortunately, air conditioners are not operated by solar cells but by mains electricity, which leads to high CO_2 emissions and contributes to global warming. Therefore, the characteristics of adobe homes are favourable to changes in the climate.

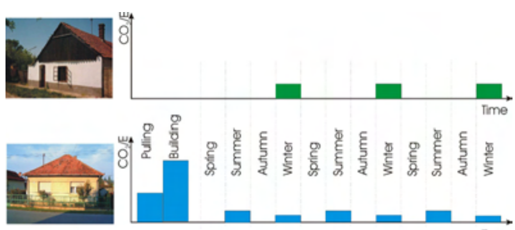

Figure 8 – Comparison of the life cycle of original adobe walled houses and brick walled houses substituted the original buildings

In winter, only heating demand requires energy in the case of adobe houses. In the case of newly-built houses, demolishing the old house, constructing the new house and heating/cooling the space all require additional energy (*Figure 8*).

The environmental impacts of adobewalled houses are lower than those of brick houses (which were built to replace them) since adobe-walled houses need heating only in winter. In summer the indoorclimate is very comfortable. Newly built houses are likely to need less heating in winter because they have better insulation. However, in summer the building can often be very warm inside. We can conclude that adobe walled houses have good energetic performance (16 – 20). Finally the demolition of adobe walled houses and the construction of new houses both need additional energy (*Figure 8*).

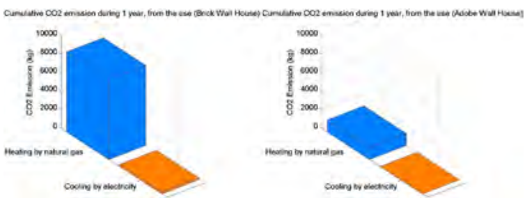

Figure 9 – Results of LCA analysis

We conducted an LCA analysis with the help of the software "Gabi" (30). The results related to CO_2 emission generated by heating and cooling are shown in *Figure 9*. Unfortunately, adobe-walled houses are associated with poverty and underdevelopment in Hungary. Therefore, most people have them demolished and have brick houses built instead. Among the educated population, building adobe-walled houses has become fashionable again. People educated with higher education are more concerned with the environment and they are looking for healthier and more environmentally-friendly solutions. Nowadays many publications have been written about adobe clay architecture but unfortunately not enough to change the public attitude.

Outcomes and results

The most important argument against adobe-wall buildings in the past was they are quite uncomfortable, however this objection is nowadays no longer valid as high-tech building technologies (e.g. water-tightness) have eliminated this disadvantage. Sometimes the dwellers feel embarrassed that they live in an adobe building, therefore they shape and plaster the appearance of their house, as if the wall is made of brick. Although the excellent physical features of the building remain, the value of the cultural heritage is lost.

The main enemy of such an adobe wall building is water (rain, splashed water and ground water). The walls are susceptible of becoming wet if van der Wall forces between Sum-micron particles keep the building materials together instead of chemical bonds. As a result of the humidity, the bonding force weakens.

The most important aspect is the roof structure and the cover of the house, which have to be perfectly built. There are several solutions on the market available for water insulation against ground water, including pressed metal plate built-in into the wall, different chemicals inserted into several drilled holes etc.
This solution can be achieved individually. Bevel holes must be drilled into the wall above the ground-wall and they have to be filled with chemicals. The chemicals are absorbed by the wall and thus insulate it. It is a cheap and simple solution.

In many cases, there is need to renew neglected buildings. Continuous rain and damaged roof can crack the wall; therefore humidity must be eliminated to save the wall. Inorder to stop the wire ropes are fixed to the wall. The fragile surface of the adobe wall cannot hold any painting or plaster, hence there will must be a thin wire mesh fixed on it with large nails, and it must be plastered with a thin layer in a traditional manner. The building with the renewed adobe wall will be more energy efficient and healthy (e.g. humidity balancing), furthermore its traditional space enables a very calming mood.

4. CONCLUSIONS

In this work we showed that in Vasvár region (and also for the whole of Hungary) the adobe clay architecture corresponds to the climate, which is proved by vernacular architecture. It is highlighted that preserved and energy efficient adobe clay buildings can present representative cultural heritage.

The presented project started about 10 years ago with the preservation of adobe press-houses (31 – 33). As press-houses are only temporary homes, there is no energetic data available about them. There are no energetic details concerning residential buildings, so regarding energetic and CO_2 emission, we can only provide quantitative results from LCA analyses. There are no specific measurement results available now.

If we can avoid building new houses, we can reduce CO_2 emission. In addition, air-conditioning is unnecessary in the summer, so we can also avoid CO_2 emission and save fossil energy sources.

According to calculations, during the renovation of adobe houses, these houses can reach category D through these investments. Energy consumption can be reduced by 45-50 %, saving up to an estimated 260 kWh/m^2year. This means saving 1100 m^3 of gas per year in the case of a 50 m^2 heated area. In hungarian florints it means saving 150,000 Hufs per year, corresponding to €500 per year (23).

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