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Climate Parameters in Built Environment from Energetic Point of View – Towards Climate Severity Index in Hungary

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Abstract: *The building energy sector is not immune from the physical impacts of climate change and must adapt. The impacts are more gradual, such as changes to heating and cooling demand. Disruptions to the energy system can also have significant knock-on effects on other critical services. To improve the climate resilience of the building energy system, governments need to design and implement frameworks that encourage prudent adaptation, while the private sector should assess the risks and impacts as part of its investment decisions. Comprehensive studies covering the impact of climate change on the building energy sector are still lacking, though some regional and sector-specific analysis exists. The buildings sector has been examined in more depth than most, with studies finding that temperature increases are expected to boost demand for air conditioning, while fuel consumption for space heating will be reduced. For the follow-up research activity the question has been posed: How can the climate changing trends and the building sector rising energy demand meet in urban environment? As an outlook this present paper can be defined as an ex-ante document in the DENZERO Project towards generating the Hungarian Climate Severity/Energy Index.*

Keywords: *Climate Change, Energy Efficiency, Built Environment, Building Sector, Hungary*

1. INTRODUCTION – POLICY BACKGROUND

Policy support for energy efficiency of building sector has increased considerably over the past decade. Two drivers underpin this trend: first, the effort to constrain growth in greenhouse-gas emissions and, second, concerns to diversify the supply mix (promoted particularly by high oil prices, especially in 2005-2008). To address these concerns, more and more governments are adopting targets and taking measures to increase the share of renewables in the energy mix and to improve energy efficiency of built environment. [1,2]

One of the major challenges faced by European countries today is the reduction of CO^2 emissions that contribute to climate change, and one of the key areas where improvements could be made easily and at low cost is the energy efficiency of buildings.

There is an urgent need nowadays to reduce current levels of GHGs emissions. On the other hand the EU countries largely dependent on energy imports are vulnerable to disruption in energy supply which may in turn threaten functioning of their current economic structure. The EU imported 54% of its energy sources in 2006 and was projected to increase even further by 2030. Reducing its import dependency EU is one of the main goals of the 20-20 by 2020 target – this legislative package is believed to reduce the expected imports of energy by 26% compared to the development before the 20-20 initiative. One of the most important environmental problems is the energy consumption of the buildings. The current paper shows that buildings can deliver large energy and CO^2 emission reductions at low costs. The directives and the methods of the energy certification of the buildings spread across Europe. Only 1-2% part of the building stock is exchanged every year, so it is very important to increase the energy efficiency of the existing buildings, too. [1,2,3]

Climate change has a dual implication on the built environment: on one hand human settlements are vulnerable to climate change and on the other hand the building sector has a significant climate change mitigation potential. The relevant sustainable development and building policies, as well as the building design, construction and maintenance should jointly respond both to adaptation to and mitigation of climate change. [3,4]

The possible impact of the climate change on the buildings may be grouped as: the direct impacts on structure (snow load, wind pressure, landslides, flood etc.), on building constructions (fastening systems, water supply system, shading etc.) and the implication on building materials (frost-resistance, UV-resistance, fadeless etc.) and the indirect impact on in-door climate (temperature, relative humidity etc.) also. On the other hand, the town level mitigation potential assessment is also based on the building stock analysis. The building sector has a large potential for saving energy. Nowadays, in Europe 35-40% of total energy consumption is used in buildings. Almost 70% of this is dedicated to heating and cooling systems. Buildings are the highest CO^2 emitters, far ahead of the industry, transportation and land use for agricultural purpose. Energy bills are more and more significant parts of the family budgets and public institutions as well. Heating is responsible on the first place for the natural gas import dependence of the country, Hungary. [3,4]

There is also a broad scientific consensus that the energy efficiency improvement in building construction and maintenance has negative or zero costs. Nowadays, city planners and municipal decision makers have a significant role and responsibility in mitigation of and adaptation to climate change. City developers often face the problem of having no reliable information about the actual energy performance of their building stock and the cost efficient way of improving the building's energy efficiency as well as the climate vulnerability of their settlements and the options to enhance the resilience of built environments. [3,4]

2. HUNGARIAN CLIMATE

The annual averages of temperature are very similar to the well-known wave of the global temperature since the beginning of the 20th century.

The warming exceeded 0,76°C for the period 1901-2004, and its value is at least 0,38°C calculating the lowest border of the 90 % confidence interval. The annual average of temperature is 9,96°C in Hungary for the standard normal period 1961-1990. Hungary for the standard normal period 1961-1990. [3, 5]

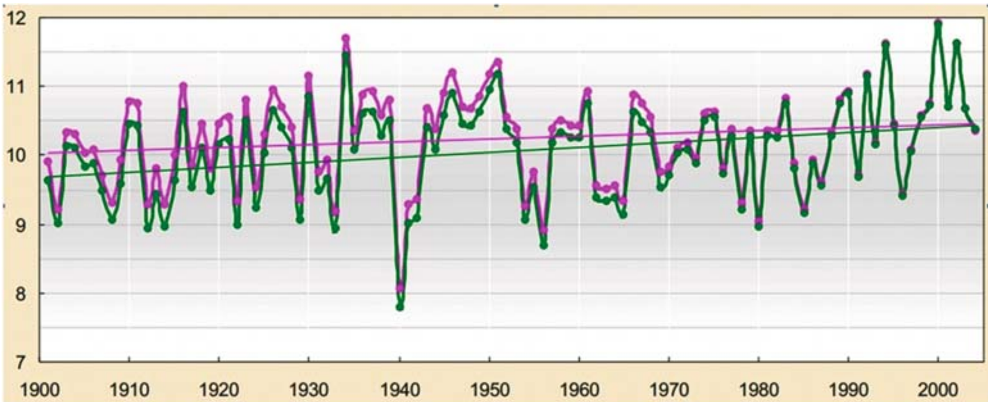

Figure 1. Annual average temperatures (°C) in Hungary for the period 1901-2004. Purple: original time series; green: homogenized time series. The warming is 0,76°C by linear estimation at the homogenized, and 0,42°C at the original time series for the 104 years. The 90 % confidence interval of the estimated trend of homogenized time series is (0,38; 1,14) [3,5]

The map of annual mean temperature of Hungary shows zonality modified by topography. The largest part of the country has an annual mean temperature between 10-10,5°C for the period 1995-2004, but higher than 11°C can be found on the south part of the country and on south, south-west slopes generally. [3,5]

The warming was less than 0,5°C between the first two decades of the period 1975-2004, with some higher values in the center of the country, the difference is more than 0,5°C between the last two decades of the same period, with the highest values on the eastern and western sides of the country. The annual average temperature grew in both periods in the whole country, but spatially very unevenly and to a greater extent in the second half of the time interval. [5] The increasing CO level of the atmosphere is one of the most important factors in the strengthening of greenhouse effect. It concentration reached 375 ppm globally for nowadays, which is higher than at any time in the last 20 million years. The CO concentration has been measured at the Hungarian background monitoring stations since the beginning of 80s, and its value raised by more than 10 % since then. It was more than 380 ppm in 2005. [5] The CO^2 background concentration in Hungary is somewhat higher than the global one which is measured above the oceans, far from any pollutants. [3,5]

Total final consumption (Total final consumption is the sum of consumption by industry, transport, buildings (including residential and services) and other (including agriculture and non-energy use). It excludes international marine and aviation bunkers, except at the world level where these are included in the transport sector.) grows at an average annual rate of 1.2% through to 2035. The buildings sector, which uses energy for heating, cooling, lighting, refrigeration and for powering electrical appliances, is currently the single largest final end-use consumer.

The demand in this sector is projected to grow at an average annual rate of 1.0% through to 2035, an overall increase of 29%. The bulk of the growth is in non-OECD regions, in line with faster population growth rates, rapidly increasing markets for electrical appliances and less stringent building standards than in the OECD. Global growth in energy use in buildings is underpinned by a 52% increase in residential floor space and a 116% increase in the value of services. Electricity's dominance of energy use in buildings grows, mainly at the expense of traditional biomass, which becomes a less important energy source for households in developing countries. [3,5]

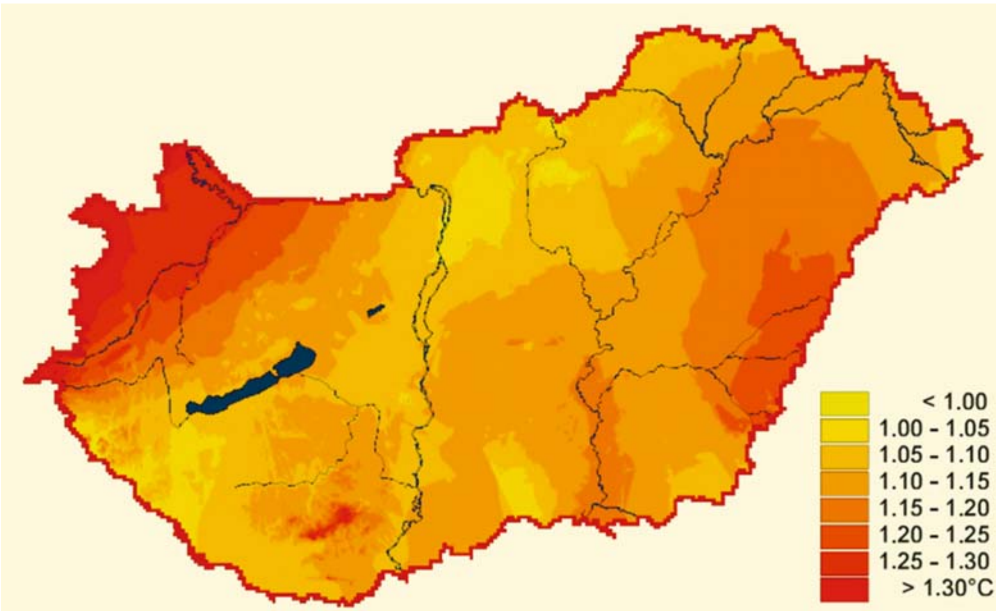

Figure 2. Change of the annual mean temperature in Hungary between 1975-2004.
The results of the linear trend estimation are relating to the 30-year long interval [3,5]

Security of supply: Hungary is highly dependent on energy source imports, and fulfils 80 percent of its domestic crude oil demand, and over 83 percent of its natural gas consumption from imports, primarily from former CIS countries (due to the limited hydrocarbon reserves of the country, the share of imports may increase further). Through the use of renewable energy sources, the dependency on imports can be reduced, as the use of renewable energy is planned to be realised from domestic sources. [3] Energy saving. The most efficient and successful implementation methods to increase the security of supply in the near future are the reducing of the primary energy consumption and the increasing of the energy efficiency. The common aim is the increasing the inland primer energy use (1085 PJ in 2010) by only 6% till 2030. But it won't be more than 1150 PJ, that was the average value in years before the economic crisis. It can be created with the reducing of CO^2 emissions and fossil-energy use. [3]

If the energy consumption reaches the amount of 1150 PJ, the energy intensity will drop rapidly because of increasing of gross national product is associated with an almost stagnant energy consumption. As a result, import dependency of inland fossil-fuels and fluctuation of the energy prices can decrease. [6]

This is the reason of the buildings renovation – most of all in case of public buildings – has priority. The aim of energy strategy is to fall of 30%-40% at heating energy demand till 2030 in accordance with guidelines of EU building energy program. On the other hand, the development of the power generation and distribution plays key role in improving energy efficiency, and in reducing energy demand of the industrial and transport sector, too. [3,6]

Environmental sustainability and climate protection. The use of renewable energy sources contributes to the reduction of CO^2 emissions. When selecting specific applications, environmental and nature conservation considerations have special priority. An important means of ensuring that environmental and nature conservation aspects are taken into account is to include them as criteria for the having regard in particular to the establishment of aid schemes. [3,6]

A significant part of energy efficiency increasing is the building energy efficiency program. Nowadays the 40 % of total energy consumption in Hungary is the energy need of the building stock, and two-thirds of it is for heating and cooling. 70% of the building stock (about 4,3 million) does not fulfil the technical (EPBD) requirements. In case of the public buildings this rate is almost the same. [3,6]

3. TRADITIONAL BUILDING ENERGY CALCULATIONS

A heating energy is necessary, if a day has lower average daily outdoor temperate than the heating design temperature. This day has a Heating Degree (HD) value. Calculation of Heating Degree value of a heating day:

$$HD = t_i - t_{em} \qquad (1)$$

where:
HD - Heating Degree [°C];
t_i - Indoor temperature [°C];
t_{em} - Daily average outdoor temperature [°C].

Heating Degree Day (HDD) value is a measurement designed to reflect the approximate (Heat requirements are not linear with temperature, and heavily insulated buildings have a lower “balance point”.) demand for energy needed to heat a building. Calculation of a heating period Heating Degree Days [3]:

$$HDD = \sum HD_n = (t_i - t_{em,1}) + (t_i - t_{em,2}) + \ldots + (t_i - t_{em,n-1}) + (t_i - t_{em,n}) = D\,(t_i - t_{em,a}) \qquad (2)$$

where:
D - Number of the heating days, heating period,
$t_{em,a}$ - average outdoor temperature of the heating period [°C].

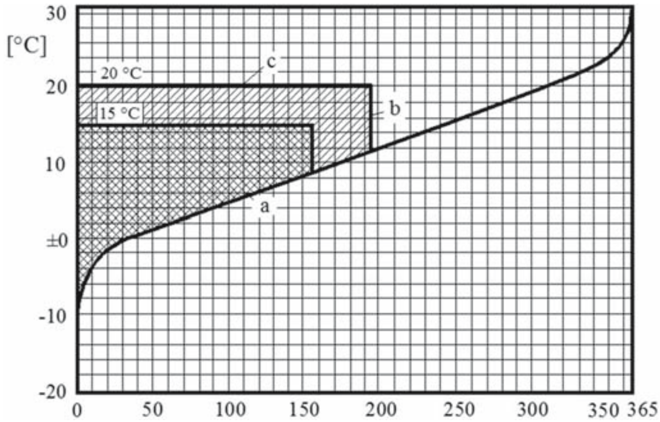

Figure 3. Heating analysis chart of Hungary, Line A: average daily outdoor temperature,
Area B: Heating energy demand with indoor temperature: 20°C,
Area C: Heating energy demand with indoor temperature: 15°C [3]

Energy demand (Area B, C) displays a significant elasticity to (indoor, outdoor) temperature changes, and temperature changes will have a different impact on the energy demand according to regional distribution at global level. If a warmer climate will be at high latitude it will tend to reduce space heating demand and thus fuel consumption (heating effect), whereas at lower latitudes cooling loads will increase with higher temperatures (cooling effect) [3].

This means that global warming will increase electricity (cooling) demand but overall energy use could instead decrease (heating).

It has to be taken into account that tradition building energy calculations focus only for heating energy (only outdoor temperature). It does not contain other climatic parameters like wind, rain, solar potential. It has to be highlighted to take these parameters into account.

One of the most important strategic objectives of Hungarian energy efficiency policy is to optimise the joint implementation of the security of supply, competitiveness and sustainability as primary national economic goals, while also taking into account long-term considerations. There can be various forms of interaction between the aforementioned three goals – in many cases their implementation may conflict with one another, but they may also strengthen each another [3].

On the other hand, the other most important aspect of the urban development strategies is the climate protection planning in order to reduce the emission of green houses gases (mitigation) and to adapt cities and buildings to the future climate conditions. For city developers it is essential to estimate the amount of the produced CO^2 by the buildings in the city and the distribution among the districts in order to set-up mitigation reference goals.

4. CONCLUSION

Buildings account for more than one-third of our planet's total energy use and associated greenhouse gas emissions, and also represent our largest and cheapest global potential for making reductions. Using existing and proven technologies, we have the ability right now to reduce energy consumption in new and existing buildings by 30-50 percent at extremely low or no cost, and usually at negative cost. The relevant sustainable development and building policies, as well as the building design, construction and maintenance should jointly respond both to adaptation to and mitigation of climate change.

The relevance of climate change cannot be negligible. Existing traditional building energy calculation does not contain the local/nearby climate parameters. The main constant design parameters must display a significant elasticity to (indoor, outdoor) temperature changes. Energy planners have to take into account the local/nearby increasing outdoor temperature in the building energy design more precisely.

As an outlook this present paper can be defined as an ex-ante document in the DENZERO Project. The question has been posed: How can the climate changing trends and the building sector rising energy demand meet in urban environment? For the follow-up research activity a National Climate Energy Index will be generated for Hungary. It will be highlighted from energetic point of view and contain the following energetic parameters only:

- Annual average temperature in Hungary [°C]
- Annual average rain water quantity in Hungary [mm]
- Annual average solar gain in Hungary [MJ/m^2]
- Annual average wind speed and direction in Hungary [m/s]

These parameters should be analyzed at national level using certified mapping tools.

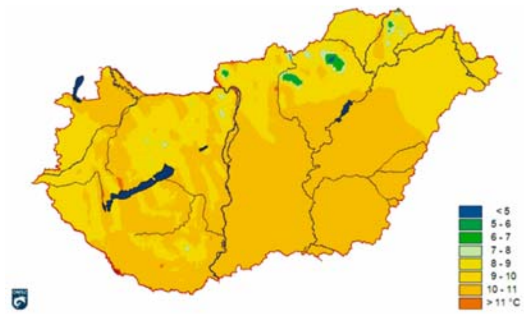

Figure 4. Annual average temperature in Hungary [°C] [OMSZ]

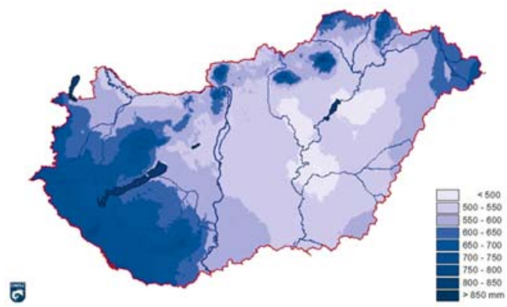

Figure 5. Annual average rain water quantity in Hungary [mm] [OMSZ]

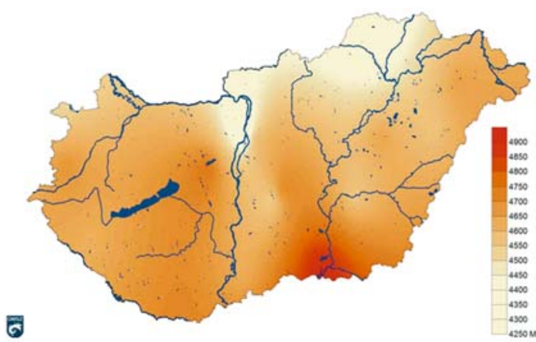

Figure 6. Annual average solar gain in Hungary [MJ/m^2] [OMSZ]

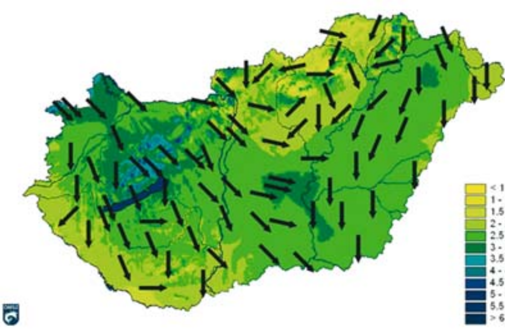

Figure 7. Annual average wind speed and direction in Hungary [m/s] [OMSZ]

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