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Locality, Mobility and Energy Sustainability in Settlement Planning

Abstract

The paper looks at causes and effects of mobility needs and key fields of energy use with a view to the Jevons paradox and the rebound effect. They may be the results of the faulty paradigm which claims that both mobility and energy use are ways of development. Issues like correlations between distance and the appropriate means of transport, organisation of family, business and personal life, travelling shorter distances and less frequent travel, distant learning, teleworking, reduced shopping, transformation of community life are rarely considered. Intermediate solutions include switch to public transport or alternative means of transpor. The same line of thought is applied to the relation of energy use with climate, culture, habits and comfort, various heating solutions and the respective role of production, trade and services. In a special case study, the eco-village of Gyűrűfű is also analysed. Here, the transport needs should be further reduced, while other energy intensive sectors—for example residential heating and power generation—are being developed into a full-fledged sustainable solution using solar systems and biomass installations.

Key words

Locality; Mobility, Energy use; Jevons paradox; Eco-villages

1. Introduction

Since the physical limits to the growth, human society has been demonstrated beyond doubt by system scientists (MEADOWS, D. H. *et al.* 1972; 1992; 2004), discussions are afloat on how to differentiate quantitative growth from qualitative development, and what kind of boundary conditions a truly sustainable society should observe. Sustainability in this sense is, a social formation of the human race which can adapt to the changing environmental factors with flexibility, without inevitable collapses as it happened throughout history all too often (PONTING, C. 1991; DIAMOND, J. 1995). According to ecological footprint analyses, energy use is the most problematic of such boundary conditions, since currently there is disequilibrium in the rate of use and rate of availability of various energy forms, including renewables (LEGGETT, J. 2005) and their environmental impacts are also thought to be far beyond the limits. Some suggest to decouple increased energy use from economic growth, but it is not quite clear how this could be accomplished on a large scale (DAUNCEY, G. 1987). In the present paper we deal with energy issues—directly or indirectly—pertaining to human communities. It seems a crucial area, as in the EU 44% of the final energy is used in buildings (domestic, tertiary or industrial buildings) and 33% is consumed by the transport sector. Moreover, both areas play an increasing role in energy consumption and environmental stresses (EC, 2013).

Creating sustainable human settlements is arguably a challenge for the 21st century. The key issue is energy use in all aspects: construction, employment, transport of goods, passenger traffic, heating, cooling, social organisation, etc. have a price tag in terms of energy. One of the approaches considered for setting up ecologically sound solutions is the concept of intended communities (HAJNAL, K. 2004) in a better known term eco-villages (BANG, J. M. 2012). The proper design of such intentional communities requires competent systems thinking if it is to be a success in terms of sustainability (BORSOS, B. 2013).

2. Theoretical background

It has been observed that energy policies introduced in the past decades to save energy had no significant effects on the overall energy use of society. As one of the most environmental-conscious communities, the European Union has introduced several policy measures to decrease environmental effects of it, yet overall transportation and CO_2-emissions grew by 15% during the last 20 years (EC, 2013). The more energy efficient solutions we use, the more energy will be needed for further economic growth. The phenomenon is known as the *Jevons paradox* and the *rebound effect* (POLIMENI, J. M. *et al.* 2009). However, most authors only state the problem and cite a wealth of evidences to substantiate their claim, but fail to suggest any solution or have only ideas with limited scope to combat the problem. For instance, it has been shown that money saved on energy efficiency will be spent on other uses, also implying energy consumption. Economic regulatory measures (taxation, selective preference to sectors, etc.) however have only a very narrow impact range (ANTAL, M. – VAN DEN BERGH, J. 2014). The old dilemma here is still whether we prefer technology versus frugality at any price, or are there any reasonable scenarios where the two can be combined (ELGIN, D. 1981). The correlation between economic growth in terms of products and services and related energy use goes far beyond the scope of this paper and implies economy theory just as well as philosophical issues such as why do we need more and more energy, increased mobility all the time? Do they really enhance the quality of our lives? Do economic growth and energy use correlate so strongly indeed? What are the causes and effects of mobility needs in communities?

3. Transport

The faulty and damaging paradigm is that most economists and decision makers consider growing mobility as an inevitable drive of development. Correspondingly, *European Union* or national level regulations do not have *any* objective to limit the extent of transportation needs in the first place. Moreover, some of them like export subsidies even assist freight transport deliberately. As a general consequence, they contribute to increasing freight transport at EU-level and at the level of the member states. As for the modal distribution, three quarters (75.5%) of all freight was transported on roads—as it is the most handy solution—in 2011. Also transport traffic became three times more intense in *Hungary* between 2000 and 2010, mostly as an adverse effect of the country's accession to the *European Union*. In terms of personal transportation, the car, valued for freedom, comfort and pleasure, became the dominant solution with continually growing annual mileage. Passenger cars accounted for 84.1% of inland passenger transport in the EU–27 in 2011 (EC, 2013).

The freedom and comfort provided by passenger cars have their price tag as, according to comparisons and life cycle assessments (LCAs), car is the most damaging and resource demanding way of transport (MACKAY, D. 2009; DAVE, S. 2010). This is the reason why a number of regulations focus on the mitigation of associated environmental impacts. However, in order to reach the proper results, it is not enough to improve technical solutions, influencing the human factor is crucial just as well. It is ever more necessary to give up our demands on individual transport and promote public transportation, car pooling and community based solutions such as car sharing. The distance to be covered should be a decisive factor in shifting to appropriate and less polluting means of transport like cycling. Moreover, in order to reach shorter distances and less frequent travel, it is important to reorganise the life of families and businesses. For this purpose there are widely accepted and well-proven methodologies such as distant learning, teleworking, reduced and concentrated shopping which may become more widespread in the near future (KEMP, M. 2010). Such changes are not a function of technological changes any more, but a question of awareness and willingness, changes in personal attitudes.

Since the main environmental impact is connected to their energy use, it is important to examine the life-cycle energy consumption of different means of transport. As DAVE, S. (2010) calculated, walking and cycling (including electric bicycles) are associated by far with the least consumption of energy. The most significant element of the energy mix with regard to cycling is infrastructure, namely around two-thirds of the whole energy usage is connected to building and maintaining the components of the road network. Electric bikes have power consumption as well, but it is around 0.5% of the whole energy consumption throughout their life-cycle. Compared to an ordinary bicycle, production of electric motors and batteries for electric bikes increases their overall energy usage by 10%.

According to the analyses (MACKAY, D. 2009; DAVE, S. 2010), an efficient and well-managed public transportation system also has relatively low per capita energy consumption. Generally, trains are best in this field. About 50% of their consumption is related to operation when they use 3–9 kWh/100 seat-km. We also have to add that electric trains perform significantly better in terms of energy efficiency than diesel trains. Around 30% of the whole life-cycle energy consumption is associated with infrastructure. Buses in average consume 30–35 kWh/100 seat-km in real life operation (67,600 km/year for 12 years) which accounts for about 75% of their whole life-cycle energy usage. Looking at disadvantages of public transportation, the biggest problem emerges, if public transport systems are run inefficiently and underutilised. In fact, per capita energy consumption in half-empty buses can be 8–10 times higher than their average; therefore, it exceeds that of even the least efficient SUV *(Figure 1)*.

Sometimes, good intentions seem to be marred by harsh reality: the *Centre for Alternative Technology (CAT*) in *Wales* was set up as a research, education and demonstration centre for environmentally sound energy use (SHEPHERD, A. 2014). However, visitors are pouring in by fossil fuel powered cars and there is only a slight chance that upon returning to their respective homes they will change their lives in reaction to what they have seen in *Wales*. Thus, the entire effort is more of a tourist attraction triggering even more mobility. Unfortunately, many eco-villages also attract thousands of visitors, sometimes from large distances; therefore they play a similar role. On the other hand, for instance, transport needs can be drastically reduced by insisting on local food from nearby agricultural areas—even when the settlement pattern is not specifically a sustainable one (SPECTOR, R. 2002).

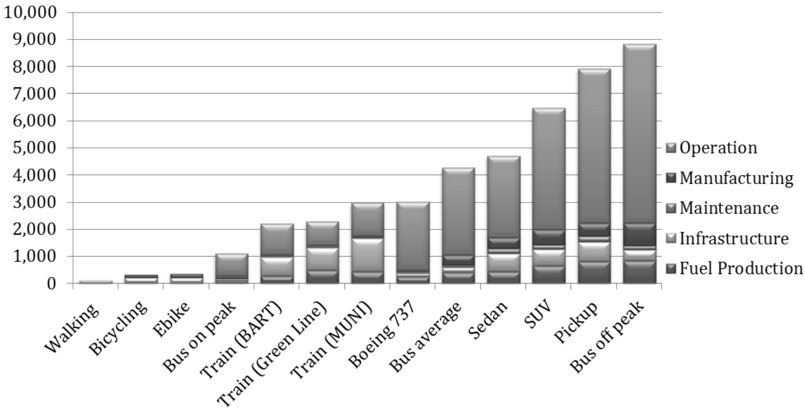

Figure 1 – Energy input per passenger-miles (kJ/PMT) for various transport options throughout complete lifecycles

Source: DAVE, S. (2010)

4. Energy

There is also a widely held but faulty paradigm concerning energy consumption in general: it claims that our standard of living depends on an ever-increasing amount of energy we use—to heat our bigger homes to higher temperatures, to provide more transport and to produce increasing quantities of manufactured articles in the western style of life (TODD, R. W. – ALTY, C. J. N. 1977). There are several other cultures worldwide, but the spread of western lifestyle destroys traditional local societies. As a result, local living strategies and traditional knowledge disappear and ultimately overconsumption, depletion of natural resources and contamination of the environment occur.

The process involves the gradual vanishing of traditional local clothing and building solutions. In tropical *Asia* and *Africa*, managers in business districts wear Anglo–Saxon-style jacket and tie and work in huge glass and steel palaces. The trend wears down traditional values, and triggers energy needs. Fully clothed businesspeople need decreased room temperature inside these greenhouses which can be achieved by powerful air-conditioning installations only (BARRETT, M. 2007). In contrast, underdressed people during the long and chilly evenings in colder climates often claim increased inside temperature which can also be reached only with extra fuel use and extra environmental burden (OKUKUBO, A. 1984). The problem was first recognised in *Japan*, and a "Cool Biz" campaign was introduced in 2005 as a logical consequence. Government ministries were to set air conditioner temperatures at 28°C in the summer period of the year and special dress code was advised without jackets or ties. The measure was a success, and after the *Fukushima nuclear accident* the government launched the even more ambitious "Super Cool Biz" campaign in 2011 to cope with energy shortages (BBC, 2011).

These examples draw attention to the fact that challenges of energy management are by far not only technical issues and strongly relate to human behaviour.

The human factor is involved in the choice of heating systems in *Central Europe*. Modern residential buildings have much bigger floor area and more rooms than those in the past. In densely populated areas, to heat these new and more complex buildings, district heating and central heating systems are used. For convenience, the same temperature is expected to be present in all premises. Heating all rooms requires more energy even when differences in insulation systems are considered than the traditional approach with standalone heating installations like tiled stoves and mass stoves which generally heated only the most frequently used living areas of a building. Zoned heating is not consistent with the requirement of ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) on the uniformity of temperature, seen indispensable to personal comfort. However, a competing concept emphasises *thermal comfort*, a mental condition contributing significantly to occupant satisfaction with indoor environment.

Thermal comfort is also a cultural condition, related to inside temperature in general. Trends in the *United Kingdom* are well documented in this field. According to MACKAY, D. (2009), the average wintertime temperature in British houses in 1970 was 13°C. It was estimated to be 16°C in 1990 and had increased to 19°C by 2002 (DTI, 2006). The rising tendency, coupled with the growing demands of residents, is seen everywhere in the industrialised world. However, higher temperature results only partly from burning more energy, it also has to do with better insulated buildings and less loss of heat. Houses built before 1900 are 2°C colder on average than those built since 1980 (WILKINSON, P. *et al.* 2001). The explanation is provided by a change in the regulation. After 1969, it was compulsory to build homes with heating systems capable of maintaining temperatures of 18°C in living areas and 13°C in the kitchen and passageways (BOARDMAN, B. 1991). Current *EU regulations* will change energy performance of buildings in the *UK* further–the *UK* is being the only country which strictly adopted all the relevant EU rules (VERMANDE, H. M.– HEIJDEN, J. 2011). One of these rules is the new *Energy Performance of Buildings Directive* (Directive 2010/31/EU) which requires to move towards nearly-zero energy buildings by 2020 (2018 in the case of public buildings).

Irrespective of regulations, one should put on more clothes rather than rise indoor temperatures, if s/he wants to avoid feeling cold. Thermal comfort can vary by person and therefore people can adapt to their own individual levels of warmth as required (KEMP, M. 2010). The simple but efficient stove systems mentioned earlier can store thermal energy and put out the heat for 8–36 hours. They cannot maintain a certain temperature, but a relatively small range of temperatures (SZALAI, P. – MUNKÁCSY, B. 2008).

More efficient heating technology and better insulation may ensure financial savings. Funds thus liberated may be put to good use like further energy saving investments, or—better still—they do not need to be earned in the first place. Unfortunately, such money can also be spent on further energy consuming services or products, starting the rebound effect—depending on their owners' awareness.

5. Seeking a more sustainable solution

A number of reviews and analyses argue (IDA, 2006; IDA, 2009; ALLEN, P. 2013) that our energy demand in the future should be drastically cut to a level which can be provided by local renewable energy sources. In this context, complete re-arrangement of the food industry and ensuring safe and sufficient, good quality local food supply seems to be one of the major challenges. Also, settlement patterns should be reconsidered in terms of efficiency, efficacy and long term sustainability. From this point of view it may be of interest to have a look at a relatively new concept, the revival (and revitalisation) of rural settlements on ecological principles.

6. A case study of Gyűrűfű: a rural setting

Gyűrűfű is an eco-village site set up in the southwest of *Hungary* at the location of a former traditional village community *(Figure 2)*. Since its foundation in 1991, this project has been subject to a number of studies, student projects and papers dealing with sustainable human settlements, or, for that matter, eco-villages (for a summary see BORSOS, B. 2007). Some conclusions can be drawn from this case study with regard to the subject of this current paper as well.

6.1. Transport

In terms of energy, design of the community focused on four areas to the extent possible: building, heating, electricity and mobility. Energy considerations pertaining to the construction activities have been covered extensively elsewhere (BORSOS, B. 2005). There are a number of distinct features which distinguish attempts of sustainable human settlements in rural setting from those in urban environment: on the one hand, some energy intensive human activities/needs have environmentally sound solutions here readily at hand: construction materials and methods, food supply, space and opportunity for alternative solutions to water supply and waste water management (reed bed systems, septic tanks, composting facilities, etc.) are available without the need for extensive transport, but a greater need for mobility seems to be inevitable for other purposes: kids to school, daily/weekly shopping, commuting to work, to cultural events, social entertaining, social ties and relations, family, friends, etc.

At any rate, it must be stated that a rural setting, as an offset, requires more movement. Additionally, local agricultural production does not solve the problem of shopping traffic. In the case of *Gyűrűfű*, the much publicised community supported agriculture model (CSA) (FISHER, A. 2002) does not seem to work. Inhabitants decide for themselves whether or not they set up a little kitchen garden which usually does not produce enough for selling and the design of the village site,

Figure 2 – The quality of the access road does not encourage easy cycling in Gyűrűfű

Photographed by BORSOS, B. (2014)

coupled with poor quality land is unsuitable for any larger scale cropping operations. Livestock husbandry is one viable option, currently not utilised to the full extent. Car-pooling works better in reducing traffic needs, and a village van for kids solves the problem of commuting to school. Bicycle use is somewhat problematic due to the quality of the access road and the distances which need to be covered *(Figure 2)*, nevertheless some of the residents eagerly and consciously deploy this means of transport as well. Maybe the spread and development of electric bicycles will improve the applicability of cycling. The closest villages and railway stations are 7–9 kilometres from *Gyűrűfű*, which means that they can be reached within 25–30 minutes by bicycles. Another 30 minutes needs to reach *Pécs*, the biggest city in the area *(Figure 3)*.

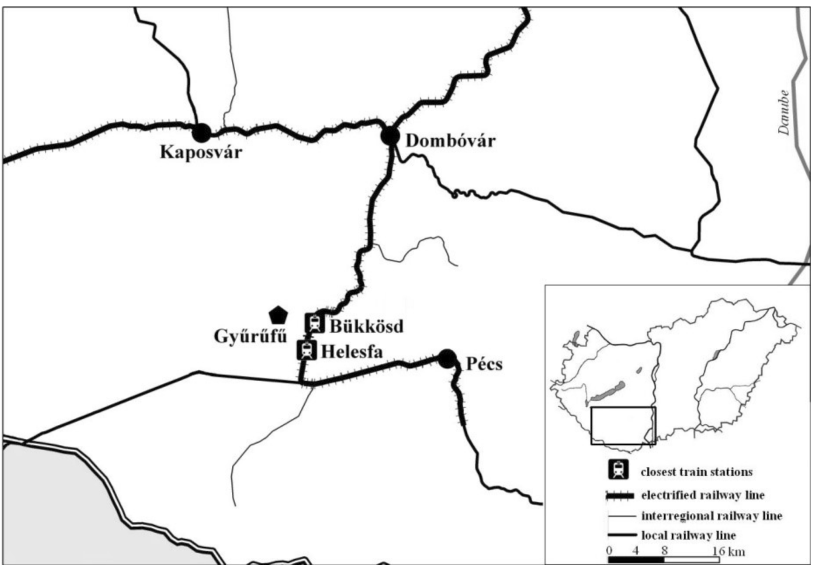

Figure 3 – The location of Gyűrűfű eco-village
Edited by HARMAT, Á. (2014)

On the other hand, there are other, more efficient ways to decrease the needs for transportation. Employment, teleworking and internet use for banking and e-government depend on individual life situations, but are promising directions in lessening mobility needs.

Planning strategy was completely different in some other eco communities. One of the most important planning factors was accessibility in the case of Danish eco-villages *Dyssekilde* and *Hjortshøj*, as they have their own train stations, which also means a superb connection to central cities. According to the railway time table *Dyssekilde* can be reached from *Copenhagen* by train in 45 minutes, while *Hjortshøj* is situated an 18 minutes train ride from *Aarhus*, the second-largest city of the country. A completely different approach can be defined in the case of *Gut Karlshöhe*, as their eco-community exists within the metropolis of *Hamburg*.

6.2. Electricity

Electric power needs at *Gyűrűfű* initially have been covered entirely through the national grid. Even though various design plans were considered for replacing fossil fuel/nuclear derived electricity from long distance transmission lines with local hybrid solutions (BORSOS, B. 1991), these attempts proved later on to be either impractical or prohibitively expensive. Therefore, the village site was supplied commercially, and energetically sound design considerations were restricted to passive solutions such as construction and building engineering technology to minimise electricity needs (BORSOS, B. 2005). However, as technology developed, costs have sunken to an acceptable level and together with government subsidies allowed the installation of solar photovoltaic panels in the past two years. Currently, there are three arrays in operation. Further development is still possible and desirable. The cost of solar systems keeps on plummeting, in the U.S. prices fell by 60% since 2011 (MEARIAN, L. 2013).

National average household electricity consumption in *Hungary* is around 1,100 kWh/person/year (MOSONYI, GY. 2011). The overall use in one cluster of the houses at *Gyűrűfű* is 18,000 kWh a year. This can be seen as a moderate consumption, if system characteristics and the consumption patterns are taken into account. The following factors need to be imputed when assessing electric power consumption in this cluster:

1. The local public utility company installed a medium voltage level transformer station (20 kV/0.4 kV) equipped with a bi-directional electric power meter for net residential metering. This is the only interface with the national grid, and this measured the consumption of 18,000 kWh in a year before the installation of the solar systems.
2. The 10 houses of the cluster are quite far apart, and are supplied from this station with the help of an approximately 600 metres long re-used second hand underground cable. In other words, the consumption figure includes the network losses of the village's own grid.
3. In the ten lots, there are about 20 permanent residents, who stay there throughout the year and most of the time. They do not include non-permanent residents (secondary school, university students 6 people) who are there only part-time, seasonal inhabitants (one family), and most importantly, guests and visitors (an average of 10–15 people, which may range up to 30 or 40 in certain times of the year) attending the guesthouse, the horse riding school and the forest school, all located within the same cluster, in season from early spring to late autumn.
4. Since there is no other public utility service installed in the village (gas, district heating, water, sewer systems, etc.), electricity is also used for non-typical residential uses like household water works, pumps from wells, and at some places electric water heaters in summer (during the winter, hot water is generated by biomass heating).
5. Many people keep livestock, do crafts and other works which require power machines (workshop machinery, stable lighting, milking equipment, electric plane, circular saw, lawn mowers, etc.) all of which actually in intensive use.

6. Most people do not commute on a daily basis: many of them have their offices, workplaces in the same house where they live; therefore, they use electricity during daytime, as well.
7. If you analyse the structure of electricity consumption like this, you will see that average figures and statistics may easily conceal many factors which may or may not increase or decrease the mean values.

Thus, at the time being, the local grid is served by the national transmission network at a single feeding point and by the three solar systems on the community house and two private houses (each with a capacity of 6.0, 5.2 and 7.0 kW, respectively). Careful design allows the three systems to generate more electricity than actually needed; therefore, surpluses are sold to the national grid. This could be achieved by optimum orientation—which is also true for the village as a whole—of both houses and the solar arrays, the site and the Mediterranean influence which comes from the south in that part of the country. Modelled production of the system gives a theoretical output of 21,000 kWh a year. However, since there is only one meter to the service provider at the transformer station, surplus electricity from the solar systems is first taken by other consumers in the cluster which also include the small dairy operation, a mixed farm and the guesthouse. Inside accounting is made on an annual basis by private power meters (RÁCZ, A. *ex verb.* 2014).

Taking into account all the aforementioned circumstances, the per capita consumption does not seem to be high; although, it is difficult to state an actual figure. Also, it would be possible to improve efficiency, mainly by the replacement of the underground cable, where network losses are relatively high.

6.3. Heating solutions

As for the energy solutions, all of the residential heating and much of hot water production is accomplished in the village by various biomass installations. Most appliances are different types of individual wood fired ovens, fireplaces, some equipped with central heating systems.

Using in part garden refuse, prunings and coppiced wood, partly firewood from the community-managed or other neighbouring forests, the carbon balance of these solutions is pretty much zero. However, they have some other—minor, at the time being, manageable—adverse implications: first of all, biomass is a resource available locally in a limited quantity and inconsiderate extraction may lead to shortages or quality impairment (at the current population size this is not a threat). Secondly, the price of wood increases as big power plants in the region *(Pécs)* switch to "renewable" sources such as timber (SZENDREI, J. 2005). As a results, the price of firewood for household has also skyrocketed from HUF 4,400/m^3 (11.2 GBP) in the year 2000 to HUF 12,000/m^3 (5.1 GBP) in 2004 (BORSOS, B. 2005). Last but not least, poorly managed fire burning appliances may entail harmful and pollutant emissions.

Due to the potential for relative fuel scarcity and some of the environmental considerations associated with biomass based heating installation alone, as a prospective future development, the application of solar collectors, heat pumps or even a district heating system may be considered.

Solar collectors present the most obvious and matured solution which can be easily combined with biomass systems and may cover the whole domestic hot water demand from March to October, without any kind of air pollution. In fact, most houses in *Gyűrűfű* already use one such system or another.

Heat pump technology has developed in recent years. *Life Cycle Assessment (LCA)* shows both economic and environmental benefits over some other solutions of heating (REY, F. J. *et al.* 2004). However, the environmental burden of the whole life cycle is mostly connected to the power consumption of heat pumps which means that the way of the power production is a decisive factor. Unfortunately, the Hungarian national power generation system with its significant (40–50%) nuclear share is amongst the most worrisome arrangements in the *European Union*. On the other hand, connected to smarter and greener local power production systems, heat pumps have the benefits of meeting three different kinds of domestic heat requirements with the use of the very same equipment: room-heating in winter, domestic hot water generation throughout the year and, finally, if poor orientation of the building or increased summer heat due to climate change require, cooling in summer. A good solution can be a combined system with on-the-spot electricity generation by either FIO (i.e. hooked on the grid with "feed-in-obligation", a scheme with preferential takeover price for small scale power generating installations run on renewable energy resources) or standalone solar PV installations. It may provide a long term, state-of-the-art autonomous local solution for most energy needs encountered in an eco-village.

District heating is by now a widespread technology with greatly improved efficiency rates; therefore, it might be considered in compact small eco-villages—but not for *Gyűrűfű* which is too scattered for such a system. Small scale district heating systems can be fuelled by local biomass or solar or ambient heat (like geothermal), or better still, by a combination of those. Supplemented with pollution control technologies it also provides a great possibility to establish a clean, efficient and cheap design (ERICSSON, K. 2009; NIJJAR, J. S. *et al.* 2009). In Danish eco-communities, like *Svanholm* or *Hjortshøj*, there are pilot programs to integrate Stirling-engines into these heating systems to create electricity, as well. Hopefully, the current problems, including the destructive resonance, will be overcome soon.

Although, no proper calculations were made in terms of per capita energy use in the eco-village, it can be predicted with confidence that the overall energy consumption and the environmental impact (ecological footprint, if you like) of residents here is a lot less (or smaller) than those of an average Hungarian. While mobility needs still should be reconsidered and further ways of lessening them or making them more environmentally sound are required, the thoughtful original spatial design and the newly opened potentials in terms of solar power and thermal heating definitely improve the overall sustainability of the project.

7. Conclusions

In a comparison of the global trends in energy use and mobility, the faulty paradigms of growth as an inevitable conditions precedent of human welfare cause severe rebound effects worldwide. Conscious design patterns with an intention to decouple human settlements from this vicious circle are necessary to benefit from improved efficiency of energy and transportation systems. The way out should be less energy use and less mobility, associated with raised individual awareness and innovative new solutions both in terms of technology and social organisation (and the merger of the two).

The role of locality should be revisited. An example of doing so is the emerging trend of eco-villages. The case study of *Gyűrűfű* demonstrates that, at least in terms of energy use and the *Jevons paradox*, small scale sustainable settlement patterns might be a way out of the trap. In the case of this sparsely populated eco-community, sustainable transportation and mobility seem to be the major challenges and continues to be the most difficult problems. According to our findings, reduction of demand, finding or creating local solutions, improving local food production or establishing local services may be some of the answers *(Table 1)*.

According to the experiences in *Gyűrűfű*, the current per capita household energy consumption can be reduced to a third by efficiency and sufficiency measures. In order to exclude the adverse consequence of the rebound effect, the combination of these two solutions may only be the solution. The decreased energy demand can be covered easily with local renewable sources, in Hungarian circumstances with various combinations of biomass and solar applications. In the medium term, use of more sophisticated ambient heat applications, such as heat pumps can help the integration of renewable energy solutions into the regional energy system.

As a direction for further study, the assessment of the eco-village's overall energy consumption over the long term would be a useful benchmark for comparison with other lifestyles. The size of such a sustainable local community including the spatial structure and settlement pattern also seems to be an interesting research topic, especially from the viewpoint of regional interdependence.

Table 1 – SWOT analysis of the pros and cons in energetics of ecologically sound attempts to create sustainable human settlements in rural setting on the example of the Gyűrűfű eco-village

Strength	Weaknesses
• Building technology • Local services (construction materials, firewood, space, recreation, local community) • Residential heating (no fossil resources) • Building engineering solutions (water, sewer, waste) • Arable land for local food production • Solar system	• Due to rural setting more need for mobility (jobs, administration, shopping, culture) • No alternatives to car/truck use • Long distances to be covered • Electricity needs from the grid • Harmful effects of firewood
Opportunities	**Threats**
• CSA (community supported agriculture, currently underutilised) • Self-sustenance in terms of basic human needs • Replacement of electricity from the grid by autonomous solar systems • Lifting threats of firewood depletion by heat pump installations run on solar power • Reducing mobility needs by teleworking, internet-based administration (e-government) and e-shopping • Increasing efficiency in all energy systems	• Long term depletion of firewood sources • Economic costs of modern installations • Continuous need for transport and passenger traffic • Environmental costs of high-tech renewable solutions such as heat pumps, solar panels and batteries • Unknown long term effects of geothermal systems with deep bore probes

8. Acknowledgement

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References

ALLEN, P. (ed.) (2013). *Zero Carbon Britain – Rethinking the Future*. – Centre for Alternative Technology, 214 p.

ANTAL, M. – VAN DEN BERGH, J. (2014). *Re-spending rebound: A macro-level assessment of OECD countries and emerging economies.* – Energy Policy Vol. 68 May 2014, pp. 585–590.

BANG, J. M. (2012). *Eco-villages: A practical guide to sustainable communities*. – Floris Books, 288 p.

BOARDMAN, B. (1991). *Fuel Poverty: from cold homes to affordable warmth.* – Belhaven Press, 267 p.

BORSOS, B. (1991). *Tulajdonképpen: mi is az az ökofalu? – Öko*, 2 (2), pp. 37–41.

BORSOS, B. (2005). *Alternatív energetikai megoldások lehetőségei a fenntartható településfejlesztés vidéki példáin: Gyűrűfű – esettanulmány.* In: *Tanulmányok Tóth József tiszteletére.* – PTE Földrajzi Intézet Pécs, pp. 111–120.

BORSOS, B. (2007). *Az ökofalu koncepciója és helye a fenntartható település- és vidékfejlesztésben.* – Pécsi Tudományegyetem, Természettudományi Kar, Földtudományok Doktori Iskola, Manuscript, 207 p.

BORSOS, B. (2013). *The Eco-Village Concept in a Model Experiment in South-West Hungary*. – *Journal of Settlement and Spatial Planning*, 4 (1) pp. 69–76.

DAUNCEY, G. (1988). *After the Crash: The Emergence of a Rainbow Economy.* – Green Print, 320 p.

DIAMOND, J. (2005). *Collapse. How societies choose to fail or succeed*. – Viking, Penguin Group, New York, 575 p.

EC (2013). *EU Transport in Figures.* Statistical Pocket Book 2013. – European Commission

ELGIN, D. (1981). *Voluntary Simplicity, Toward A Way of Life That Is Outwardly Simple, Inwardly Rich*. – William Morrow and Company, New York, 303 p.

FISHER, A. (2002*). Community food security: a promising alternative to the global food system*. In: KIMBRELL, A. (ed.) *Fatal harvest: The tragedy of industrial agriculture.* – Island Press, Washington, Covelo, London, 367 p.

HAJNAL, K. (2004). *A fenntartható fejlődés elméleti modellje és a fenntartható településfejlesztés elméleti kérdései*. – Pécsi Tudományegyetem, Földrajzi Intézet, Manuscript, 184 p.

LEGGETT, J. (2005). *Half Gone: Oil, Gas, Hot Air and the Global Energy Crisis*. – Portobello Books Ltd., 320 p.

KEMP, M. (ed.) (2010). *Zero Carbon Britain 2030 – a new energy strategy*. – Centre for Alternative Technology, 384 p.

MACKAY, D. (2009). *Sustainable Energy – Without the Hot Air*. – UIT, Cambridge, 383 p.

MEADOWS, D. H. – MEADOWS, D. L. – RANDERS, J. (1992). *Beyond the Limits – Confronting Global Collapse and Envisioning a Sustainable Future*. – Post Mills, Vermont Chelsea Green Publishing Company, 300 p.

MEADOWS, D. H. – Meadows, D. L. – RANDERS, J. – BEHRENS, W. W. (1972). *The Limits to Growth – A report for the Club of Rome's project on the Predicament of Mankind*. – Washington, Potomac Associates. London, Earth Island

MEADOWS, D. H. – RANDERS, J. – MEADOWS, D. L. (2004). *Limits to Growth – The 30-Year Update*, Chelsea Green, 338 p.

POLIMENI, J. M. – MAYUMI, K. – MARIO, G. – BLAKE, A. (2009). *The Myth of Resource Efficiency: The Jevons Paradox (Earthscan Research Editions).* – Routledge, 200 p.

PONTING, C. (1991). *A green history of the world. The environment and the collapse of the great civilisations.* – Sinclair-Stevenson, London, 430 p.

RÁCZ, A. (2014). *Energy consumption figures in Gyűrűfű.* (Personal communication, April 2014)

REY, F. J. – MARTIN-GIL, J.– VELASCO, E. – PÉREZ, D. – VALERA, F. – PALOMAR, J. M. – DORADO. M. P. (2004). *Life Cycle Assessment and External Environmental Cost Analysis of Heat Pumps*. – *Environmental Engineering Science*; 21 (5), pp. 591–605

SHEPHERD, A. (2014). *Voices from a disused quarry: Celebrating 40 years of the Centre for Alternative Technology*. 48 p.

SPECTOR, R. (2002). *Fully integrated food systems: regaining connections between farmers and consumers*. In: KIMBRELL, A. (ed.) *Fatal harvest: The tragedy of industrial agriculture*. – Island Press, Washington, Covelo, London, 367 p.

SZALAI, P. – MUNKÁCSY, B. (2008). *A tömegkályha – a biomassza energetikai hasznosításának hatékony megoldása.* (The mass stove – an efficient method of biomass energy) In: MUNKÁCSY, B. (ed.) *Az energiagazdálkodás és az emberi tényező*. pp. 58–72.

TODD, R. W. – ALTY, C. J. N. (1977). *An Alternative Energy Strategy for the United Kingdom*. – National Centre for Alternative Technology. Machynlleth, Powys, 43 p.

Electronic sources

BARRETT, M. (2007). *Energy, Carbon Dioxide and Consumer Choice.* – Sustainable Environment Consultants [online]. *(pdf)*, 110 p. Available at: <http://discovery.ucl.ac.uk/3504/1/3504.pdf> [Accessed: 10 April 2014]

BBC (2011). *Japan promotes 'Super Cool Biz' energy saving campaign.* – BBC News [online]. Available at: <http://www.bbc.co.uk/news/business-13620900> [Accessed: 10 April 2014]

DAVE, S. (2010). *Life Cycle Assessment of Transportation Options for Commuters.* – Massachusetts Institute of Technology (MIT) [online]. *(pdf)* 16 p. Available at: <http://files.meetup.com/1468133/LCAwhitepaper.pdf> [Accessed: 10 April 2014]

DTI (2006). *Energy: its impact on the environment and society.* – National Archives [online]. *(pdf)* Department of Trade and Industry, United Kingdom, 40 p. Available at: <http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file32546.pdf> [Accessed: 13 April 2014]

ERICSSON, K. (2009). *Introduction and development of the Swedish district heating systems – Critical factors and lessons learned.* – Lund University [online]. *(pdf)* 54 p. Available at: <http://miljo.lth.se/fileadmin/miljo/personal/KarinE/Swedish_district_heating_case-study_KEricsson.pdf> [Accessed: 23 April 2014]

IDA (2006). *Danish Society of Engineers' Energy Plan 2030* – Ingeniørforeningen i Danmark [online]. *(pdf)* 65 p. Available at: <http://ida.dk/sites/climate/introduction/Documents/Energyplan2030.pdf> [Accessed: 30 May 2008]

IDA (2009). *Danish Society of Engineers' Climate Plan 2050* – Ingeniørforeningen i Danmark [online]. *(pdf)* 191 p. Available at: <http://ida.dk/omida/laesesalen/Documents/UK-Future%20Climates%20Background%20Report.pdf> [Accessed: 5 February 2014]

MEARIAN, L. (2013*). Solar power installation costs fall through the floor.* – Computerworld online [online]. Available at: <http://www.computerworld.com/s/article/9244836/Solar_power_installation_costs_fall_through_the_floor> [Accessed: 10 April 2014]

MOSONYI GY. (2011). *A növekedés esélyei egy nemzetközi energetikai vállalat szemszögéből. (Chances for growth from a viewpoint of an international energy company).* – Central European Business Centre[online]. *(ppt)* Available at: <www.cebc.hu/ppt/xxi_vezer/mosonyi-gyorgy.ppt> [Accessed: 12 October 2014]

Nijjar, J. S. – Fung, A. S. – Hughes, L. – Taherian, H. (2009). *District Heating System Design for Rural Nova Scotian Communities Using Building Simulation and Energy Usage Databases.* – Transactions of the Canadian Society for Mechanical Engineering [online]. *(pdf)* In: Transactions of the Canadian Society for Mechanical Engineering. Vol. 33. No. 1. 14 p. Available at: <http://www.tcsme.org/Papers/Vol33/Vol33No1Paper5.pdf> [Accessed: 13 February 2014]

Okukubo, A. (1984). *Comparative Study of Clothing and Thermal Comfort in England and Japan with a View to Achieving Clothing Habits More Conductive to Health.* – University of Surrey [online]. *(pdf)* 463 p. Available at: <http://epubs.surrey.ac.uk/2103/1/353311.pdf> [Accessed: 12 April 2014]

Szendrei, J. (2005). *A biomassza energetikai hasznosítása.* (Biomass for energy production). – Debreceni Egyetem [online]. *(pdf)* Agrártudományi Közlemények, 2005/16. pp. 264–272. Available at: <http://www.date.hu/acta-agraria/2005-16/szendrei.pdf> [Accessed: 7 July 2014]

Vermande, H.M.– Heijden, J. (2011). *The Lead Market Initiative and Sustainable Construction: Screening of National Building Regulations.* – European Commission [online]. *(pdf)* Delft University of Technology, 110 p. Available at: <http://ec.europa.eu/enterprise/sectors/construction/studies/national-building-regulations_en.htm> [Accessed: 13 April 2014]

Wilkinson, P. – Landon. M. – Armstrong, B. – Stevenson, S. – Pattenden, S. – McKee, M. – Fletcher, T. (2001). *Cold Comfort. The social and environmental determinants of excess winter death in England 1986–96*. – Joseph Rowntree Foundation [online]. *(pdf)* The Policy Press, Bristol, 34 p. Available at: <http://www.jrf.org.uk/sites/files/jrf/jr101-determinants-winter-deaths.pdf> [Accessed: 13 April 2014]

Legislations

Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of building