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The Feasibility of Micro-regional Autonomous Energy Systems

(using renewable energy sources for regional development)

Abstract

The current and the future situations of the utilisation of renewable energy sources are contradictory. As a consequence of the present economic crisis, investments in this field are in decline all over the world. One of the most advanced bio-Diesel plants of Europe, in Orosháza, has been out of order for four years. Hungary's first biomass electric power plant, created as a Japanese–Hungarian investment in Szakoly, went bankrupt only after a few months of operation and is still out of use. In the long run, the "One Europe–One Market" idea is not very attractive for investors. In December 2012, the chairman of the Hungarian Renewable Energy Association resigned. His reasons: the use of renewable energy has lost its importance in Hungary, as the government only focuses on nuclear power and the usage of natural gas. We must all prepare for the changes in our own area, and small communities should draw their own energy strategies. This primarily means building local energy supply systems. The annual amount of 6 million tons of unused biomass, solar- and geothermal energy offers a sound foundation for such plans. In this respect, the country has great potentials. In this study, an attempt is made to draft the optimal ways of development.

Key words

Hungary; Renewable energy resources; Energy policies; Local solutions

Introduction

Hungary is located in *Central Europe*. With 93,000 km^2 (35,919 mi^2) of land covered, the country lies in the middle of the *Carpathian Basin*. Due to its central location, the country plays a significant role in energy transport in the direction of the neighbouring countries and *Western Europe* (e.g. transmission lines of electricity, natural gas and oil pipelines are running through the country). *Hungary* purchases 65% of the total primary energy resources from *Russia*. In the last few years, the country has set a target. It aims to get independence from the imported energy sources. This goal increased the utilisation of the renewable energy sources, the development of the nuclear energy and the further usage of existing oil, gas and coal reserves. The exploration of the geothermal energy has a significant role in the energy efficiency action plan. The possibility of uranium mining is genuine and is now under exploration by an Australian company.

Nowadays, several research centres are dealing with sustainability models for micro-regions. Old local communities that have disintegrated and fallen apart by now are to be re-constructed. No sustainable economy may exist without a powerful and sustainable local infrastructure. Out of the public supply and utility systems (e.g. energy, communications, water, sewers, flood defence, information networks), energy supply receives most of the attention. Public reactions to energy issues are sometimes extreme and the opinions may easily infiltrate into media and even politics. Moreover, there may be social uproars or riots that are instigated by political forces from the background as well as profit-hungry business enterprises. Energy management is an extraordinarily complex technical and financial activity that integrates a wide range of sciences: for example geology, geography, mining, chemistry, physics, meteorology, economics, law and even sociology. All of these areas are amalgamated with the special competences of the trade. Energy production and energetics in general are like football: everybody claims to know a lot about it. Undoubtedly, selecting a method for heating, operating a car or lighting the house requires a series of personal, individual decisions. Most often, it is the owner of car or the house who makes a decision; selecting central heating, stove, electricity or oil heaters (like most detached houses in *Germany* do). It is possible to continue the list with a variety of other examples. On the other hand, energy politics has to contribute to economic growth, fight against climate changes and efforts aimed at reducing the dependence on foreign energy sources. Individuals and communities alike strive to reduce the dependence, wishing to find an economic and effective solution. One of the most common objectives of renewable energy sources is that they are very often incompatible with the changing demands on the consumers' side; e.g. wind, solar energy, water and tidal power.

1. Hungary's renewable energy resources

Based on our experience, there is a lot of hostility and indifference towards renewable energy sources in *Hungary*. This is partly a consequence of experience and support. A logical, supportive government decision often generates a whole new industry. Such is the case in *Germany* where they offer an amount equal to 156 HUF (0.42 GBP) for every kW supplied to the national grid from household photo-electric panels. In *the Netherlands*, the respective amount is 160 HUF (0.43 GBP), whereas in *Hungary* it is only 22 HUF (0.06 GBP). The differences are considerable. Within the *EU*, *Hungary* is at the end of the line in terms of supporting the use of alternative energy sources. A simplification of the official procedures would be a great step forward (e.g. at the moment, 45 different official permits and licences are required for installing wind power generators). When the new price for re-supplied energy was introduced in *Germany*, 7,000 MW new solar panels were connected to the system in 2012. When there are good potentials and capital for the use of renewable energy, it appears to be simple. That is, however, not the case. There are several towns and villages in *Hungary* where readily available thermal water of 70°C (158°F) or nearly 90°C (194°F) is simply drained to sewers and rivers (e.g. *Tiszacsege [Figure 1]* has a population of 10,000 and its well yields 800 m^3 [~800 thousand litres] of hot water a day (73°C/163.4°F), 99% of which is unused and simply flows into *River Tisza*.) It would be worth surveying the degree of utilisation of the thermal wells in *Hungary*; in *Szabolcs–Szatmár–Bereg County* it is estimated at 5%. Some of them only need 3 hours of rest after thirty years of continual operation to reset to their original water output.

Figure 1 – Hungary and the settlements mentioned in this paper

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A relatively small country such as *Hungary* is unable to do a lot for the reduction of global CO_2 emission, particularly when large countries like *India*, the *Republic of South Africa*, *Russia* and others do virtually nothing in the struggle against climate change. The world-wide "Earth Protect" programme, which is a joint objective of mankind, is apparently not important to the countries mentioned. This is a business where we pay the bills (especially *Europe*), but others draw the profit. Our fight for increasing the share of renewable energy sources may, therefore, appear to be a wasted effort.

Hungary does not have a comparative advantage in terms of green energy. Today, it is clear that the 10% share of bio fuels is not realistic.

”Manufacturing” bio fuel may lead to the extermination of forests, starvation and the result of the analysis of physiological effects is also negative; ethanol is more harmful than traditional fuel. The most modern bio-Diesel factory in *Europe*, at the industrial park of *Orosháza*, has been unused for four years. The first bio-mass power station (20 MW) in *Hungary* was created as a Japanese–Hungarian joint venture in *Szakoly* in *Szabolcs–Szatmár–Bereg County*, had to be closed down after a very short period of operation. No continual supply of fuel was organised and finding the market for the generated heat did not receive due attention either. The awkward debates and discussions about the power station (based on straw as fuel) planned to be created in *Szerencs* are the signs of these sad conditions. Despite all these, it is our conviction that economic and independent energy supply organised at a regional or sub-regional level is indispensable for overcoming the relative poverty of the area and for creating a better and healthier environment. It is, therefore, justified to say that *Hungary* is extremely rich in renewable energy resources. It is, however, equally justified to claim that it is also poor, as the geothermal and other potentials are only utilised to a very small extent.

In the northwestern part of *Hungary*, biomass appears to be the most suitable and also most economic for introducing energy supply systems for small settlements. There are good examples for such energy supplies; in *Pornóapáti* (a village of 700 inhabitants in *Vas County*) a central heating power plant has been established and the local households are all connected to it. There are large forests near the village and waste from forestry and carpentry work is purchased and used as fuel heating the power station. The waste is ground to small and uniformed parts to make it suitable for the furnaces. The local government established a limited liability company for this particular purpose (organising heating production for the local community). The company purchases the raw material, pays the price to the suppliers and sells the heating energy and hot water to the end users. The local government, however, owns and runs a profit company which pays VAT after its turnover. This is an exemplary initiative.

The most difficult problem, in connection with such heating power plants tailored to small settlements, is that the raw material supply has to be very carefully planned and organised for years forward; production and transportation of the fuel have also to be calculated and contracted well in advance. Only then it is possible to guarantee the sustainability of the system.

The most economical solution—and the best way of avoiding any legal disputes that may arise later on—is that the fuel is grown on a land owned by the local government or the power company itself. When the land is leased or rented, there are usually legal disputes arise. When a farmer offers a land for use, it may appear to be useful and advantageous initially, but later when new lands are involved for growing fuel crops, the initial lease contract may generate disputes.

Unfortunately, there has been no considerable change in terms of use of the forestry and farming side products in the past 20 years. Regrettably, there is a lot of resistance against the transformation of the district heating and hot water supply systems in *Hungary*. The main reason is that the systems were originally constructed with a very low efficiency level, as energy was cheap when it was supplied by the *Soviet Union*. As the efficiency of these systems is low, the cost of hot water used is very high for district heating. The number of district heating centres in *Hungary* is 93; the respective figures in *Austria* and *Slovakia* are 588 and 500. In the *Czech Republic*, the population of which is, similar to the other two nations, smaller than that of *Hungary*, there are 650 district heating centres. In *Denmark*, 63% of households are connected to the district heating system, whereas in *Hungary* the figure is only 17%. Therefore, it should follow *Denmark's* example. In a country which is smaller than *Hungary* compared to its size and population (5.2 million), there are 450 district heating systems and, as it has been mentioned previously, the proportion of households connected to the system is 63%.

It is also noteworthy that the first district heating system in *Europe* was created in a small town in *Denmark*, more than 85 years ago. Experience, therefore, suggests that the best heating system is district heating as it is constructed at the highest technical–technological level.

A look at the sources of energy used for district heating in the *European Union* reveals interesting facts. The share of renewable energy sources is the highest in *France* (27%). In *Hungary*, it is not more than 8%, while even in *Finland*, where people live in small settlements scattered around the country, it is 11.6%. Interestingly, the share of renewable energy sources in the district heating system is also high in *Italy* with 18.4%. Another noteworthy indicator of the development level is the use of waste as an energy source. *Denmark* is in a leading position with 22.5%, while in *Hungary* 0% is the amount of waste used as fuel.

2. Solar energy

Hungary has excellent potentials for the use of solar energy. It is, perhaps, the process of global warming that explains the record number of sunny hours in 2012. In *Csongrád County* and around the city of *Békéscsaba (Southeast Hungary)*, the number of sunny hours per year was 2,300–2,645, a remarkable growth from the previously measured 1,800-2,100 hours of direct sunshine a year. (In *Rome* the average is 2,500 hours/year, in *Copenhagen* it is 1,680 hours/year.)

Fortunately, sun collectors began to spread in *Hungary* in the early years of this millennium. The market for solar energy equipment is in prosperity. The *Ministry of National Development* offers support to the population for the purchase and installation of solar energy devices through various applications. In these, there are more than 800 companies registered as contractors. Unfortunately, there is no domestic manufacturing industry for the production of solar collectors and, since *Duna-Szolár* went out of business ten years ago, sun batteries are also imported.

From an energy utilisation's point of view, the use of solar collectors is the most popular in *Hungary*. The investment required for a detached house with a family of four is 1.2 million HUF (3,240.00 GBP). The solar collector provides hot water and also serves as an additional heating device. The return period of the investment is 8 years. The equipment supplies 70% of the hot water used by the family and also contributes to heating. After several decades, 90% of the material of the collectors is recyclable. When the solar collector system is also used as an additional heating device, it is possible to save 25–30% of total heating costs. The sun collector is most economical when used with low-temperature heating systems (e.g. wall or floor heating).

It is a sad fact that solar battery systems are not yet popular in *Hungary*. The reason for that is that most families lack the financial resources required for the installation of such systems, despite *Hungary's* excellent potentials. The complicated *Sun*-following systems produce 45% more energy per average than fixed installations. The major disadvantage of these systems is that they need permanent maintenance personnel, as they are exposed to the weather and gale-force winds can sometimes cause damage to them. Solar battery systems have a great future and if a good solution is found for supplying the energy that is generated into the mains, the system will be very economical in the long run. A fix-installed kWp solar battery system in *Hungary* is able to generate 1,150 kWh of electric power per average. In order to install a 1 kWp solar energy system, a surface area of 6–7 m^2 (64.58–75.35 ft^2) is required when a crystal module is applied. For the same performance, the thin film systems need 11 m^2 (118.40 ft^2).The performances of the two systems are identical, but the latter is considerably cheaper. In order to supply energy to the mains, inverters are necessary, as the DC produced by solar cells is to be converted into 230 V AC. Moreover, there is hardly any loss at certain new inverter types (their efficiency is 98%). These systems are primarily profitable at solar battery installations that produce some surplus power.

In *Hungary*, such systems are purchased from foreign sources, primarily from *China*, *Germany* or *Japan*. The solar collectors reach the end users through wholesale companies. Quality complaints are usually the consequences of the inexperienced personnel installing the systems. There are also incorrect business enterprises in the market of solar collectors and batteries. In several towns and smaller settlements successful systems have been installed. In *Szarvas*, for instance, 50% of the town's electric power consumption is covered by solar energy. The solar energy park of *Újszilvás* is a real success story. The settlement, located in *Pest County*, has a population of 2,800. A Sun-following solar power plant has been installed. The system provides electric power for local government institutions. The construction of the system cost 628 million HUF (1.8 million GBP), 70% of which was provided by government funds. A speciality of the system is that a rotating machine always adjusts the collectors towards the *Sun* to provide the highest possible efficiency.

In *Újszilvás*, geothermal energy is used for heating 90% of local government buildings (primary school, day cares, cultural centre and the town hall). This is a dual-utility system. Water of 33°C is available which is used for heating. The water returning to the waterworks is cool (16°C/60.8°F). It is treated and supplied into the water mains for the community as drinking water. It is, therefore, not necessary to press the water back to the ground, as it is required by law in the case of low-temperature thermal waters. Except for the kitchen of the canteen, no natural gas is used at all. The local government saves an annual of 10–12 million HUF (~30,000 GBP).

3. Geothermal energy and the use of Earth's heat

Hungary has exceptionally good potentials in geothermal energy, as the geothermal gradient (Celsius/km) and the density of heat streams on the surface (kW/km^2) are much higher than the global average (25°C per km of depth/1°F per 70 ft of depth). In terms of the use of thermal waters below the temperature of 100°C (212°F), *Hungary* is only second to *Iceland*. There are 1,164 active thermal fountains in the country, several of which have water output of 3,000 litres/min. Despite the fact that the *Carpathian Basin* is not an active volcanic or tectonic region, thermal water and steam reservoirs of 150–350°C (302–662°F) enthalpy have been found.

In the plains, for example in the vicinity of *Nagyszénás*, outbursts of dry steam of 200°C (392°F) can be found. The steam comes from layers between 2,500–3,000 metres (8202–9842 ft) deep. Near *Hódmezővásárhely*, at the deep well codenamed HÓD-I, a pressure of 960 atm was measured at the depth of 600 m (1,968 ft). In spite of these advantageous potentials, the use of geothermal energy is negligible. The 3.7 PJ of utilised geothermal energy is not more than 3.5% of the primary energy use. A lot of the thermal water is used for balneological purposes, but energetic use is still low on the priority lists. *Hungary* does not have a geothermal electric power station, no refrigerating storehouses based on thermal water and the use of underground thermal water reserves for district heating is insignificant. The related legal regulations are contradictory and the problems of storing and pressing the water back to the water storing geological layers are varied and serious. The heat pump systems are not very well spread in *Hungary* yet. It is only worth constructing geothermal electric power stations when water of 105–110°C (221–230°F) is available. Despite the good potentials, geothermal energy does not play an important role in district heating in *Hungary*. There have been, however, some progresses attempted, as there are encouraging initiatives in *Mosonmagyaróvár*, *Kapuvár*, *Szentes*, *Makó*, *Szeged*, *Hódmezővásárhely*, *Csongrád*, *Veresegyház* and *Kistelek*.

4. Biomass

A comparison of heating value of black coal, brown coal, coke, lignite, natural gas, regular petrol, gas in cylinder and tank out of the fossil energy sources, and also wood shred, wood pellet, wood briquette and hay to the heating value of wood reveals the following *(Figure 1)*: the most economical fuel at current market prices is hay, as the price of a MJ is only 0.42 HUF (0.001 GBP) Wood briquettes are next with a price of 0.86 HUF (0.002 GBP) preceding lignite (1.8 HUF/0.005 GBP). The fourth is black coal, as it costs 5.2 times more than hay and 2.5 times more than wood shred *(Figure 2–3).*

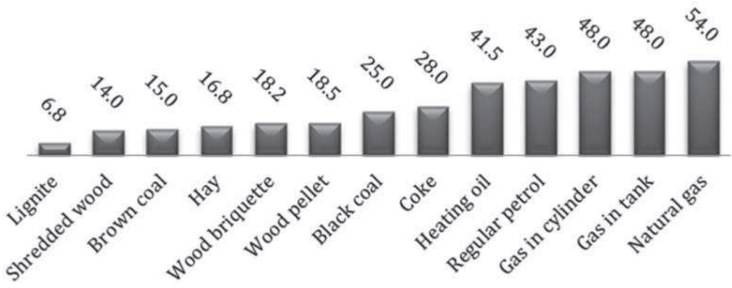

Figure 1 – Average heating values of various energy resources (MJ / kg)
Source: GERGELY, S. (2010; 2011); Edited by BOKOR, L. (2013)

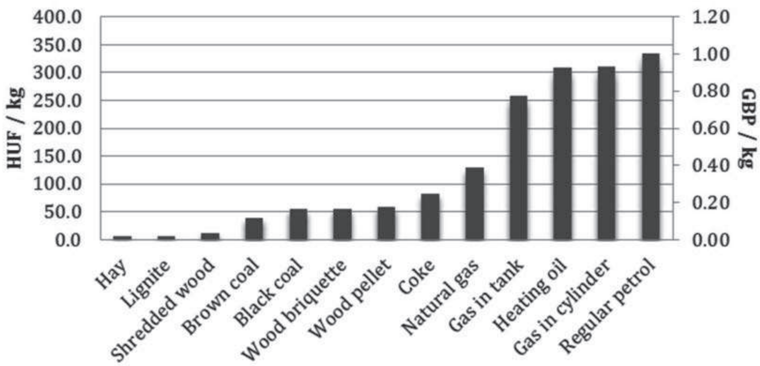

Figure 2 – Average prices of various energy resources (HUF/GBP / kg)
Source: GERGELY, S. (2010; 2011); Edited by BOKOR, L. (2013)

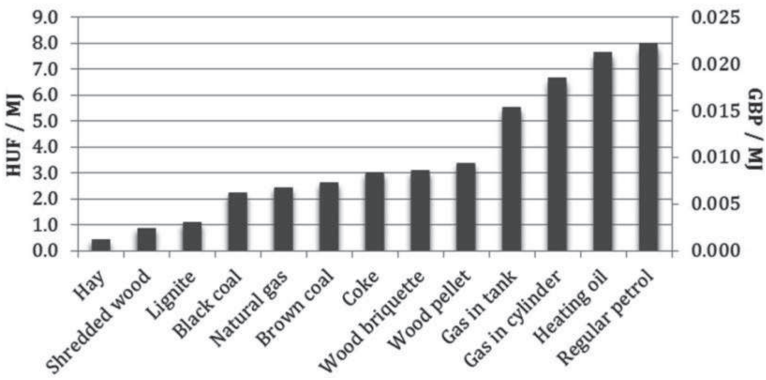

Figure 3 – Average prices of various energy resources (HUF/GBP / MJ)
Source: GERGELY, S. (2010; 2011); Edited by BOKOR, L. (2013)

In *Hungary*, the most important fuel for common heating purposes is natural gas. It retails at a price 5.7 times higher than that of hay and 2.8 times higher than that of wood shred. Lignite also appears to be an attractive fuel, but there are other problems with that. Wood contains no sulphur at all, whereas the sulphur content of lignite is 2.5–4%. The ash content of hay is a mere 4–6%, of wood it is 3–6%, but lignite contains more than 50% of ash. There have been hay power plants in *England* for decades, e.g. the one at *Sutton* near *Cambridge*, supplying power for 80,000 people.

The research literature suggests that it is only worth using wood pellets or wood briquettes under special circumstances and for special demands. In *Hungary*, the utilisation of biomass appears to be the most advantageous and economical type of renewable energy source in the future. *Hungary* has a highly developed agriculture. Therefore, the utilisation of green energy appears to be a priority in the future (in addition to geothermal and solar energy). Unfortunately, the majority of the machinery, appliances and equipment necessary for the utilisation of renewable energy sources are manufactured outside *Hungary*. At present, everything is imported. It is logical and necessary to organise the domestic manufacturing base. Since energy supply systems are planned for sub-regional purposes, there are usually seven important aspects to be taken into consideration. These are the following:

1) source of supply (where the energy is purchased from),
2) transport,
3) distribution,
4) consumption,
5) selling the energy to the end users,
6) risks in supply,
7) environmental risks.

The heating works of villages (small, multi-purpose power plants) work most effectively when they are based on locally available energy sources, because in this way it is possible to shape the most advantageous energy production system. Wood, as fuel, plays an important role. Using wood pellets and wood briquettes is only economical at already existing boilers, e. g. when there is no adequate storage facility for wood shred. Pellets and briquettes are not the ideal fuel for village district heating centres, as the net energy output may be reduced by as much as 10–25%. Firewood, waste from orchards, vineyards, wood processing plants, forestries and energy plantations may be considered as source of economical fuel. The optimum fuel supply is to be planned in accordance with the needs and specific purposes of the small power plants.

5. Conclusion

Given these facts, it can be said that firewood from the forestries may serve as the prime raw material for shredding. It is possible to mechanise the process of wood shredding. It appears to be logical to include the shredding machinery into the small power plant itself. In this way, the most suitable raw material can be easily and readily produced on the spot. Thus, it is also possible to prevent quality complaints and price debates with suppliers. A 0.5 MW village heating plant needs 1,875 tons of wood shred annually. When all factors are considered, the results suggest that areas of 70, 93 or 140 hectares are needed for the energy (wood) plantation in order to supply and operate a 0.5 MW village district heating centre. If hay is used as a fuel, it is needed to calculate with fields of 140, 186 and 279 hectares. The hay of the grain crop grown in the fields would serve as fuel. (The author's calculations suggest that 5,583 people produce 500–560 tons of communal waste. If that waste is used as fuel, several settlements must join forces and selective waste collection ought to be organised.)

It is a well-known fact that the use of fossil fuel does not have any considerable area development effect. On the other hand, the area development effect of renewable energy sources is definitely positive, as seen from some of the processes described above. The positive effects apply to employment, research development, the work of SMEs and industrialisation. Renewable energy sources have highly positive effects on living standards and human resources.

According to the 2020 energy action plan, *Hungary* has to achieve the average of 13.6% of renewable energy resources in the total energy consumption. At present, the renewable energy in the Hungarian energy balance is only 8.8%. When it comes to the latter, the traditional wood usage is the most important. The others are solar, geothermal and wind energy which account for only 3% of the renewable energy usage. According to the author, if the government does not support this development, *Hungary* will not be able to reach the action plan's goals.

References

GERGELY, S. (2010). *Magyar zöldenergia-stratégia I. – Nemzeti stratégia és energetikai stratégia.* – Magyar Energetika, 17(3), pp. 40–45.

GERGELY, S. (2011). *Megújuló energia helyi termelése, hasznosítása és a vidékfejlesztés.* LIII. Georgikon Napok. – PE, Georgikon Kar, Keszthely, pp. 291–300.

Bibliography

ÁDÁM, J. (2010). *Bevezető.* In: ÁDÁM, J. – SZABADOS, L. *Megújuló energiaforrások és környezeti hatások.* – Magyar Tudomány 171(8), pp. 906–909.

BOBOK, E. – TÓTH, A. (2010). *A geotermikus energia helyzete, perspektívái.* In: ÁDÁM, J. – SZABADOS, L. *Megújuló energiaforrások és környezeti hatások.* – Magyar Tudomány 171(8), pp. 926–936.

BÜKI, G. (2013). *Energetika a múltban és a jővőben – extenzív és intenzív fejlesztés.* – Magyar Energetika 20(2), pp. 2–6.

DINYA, L. (2010). *Áttekintés a biomassza alapú energiatermelés helyzetéről*. In: ÁDÁM, J. – SZABADOS, L. *Megújuló energiaforrások és környezeti hatások.* – Magyar Tudomány 171(8), pp. 912–925.

GÖŐZ, L. (2003). *The natural resources of Hungary. Towards a sustainable future.* – Published Bessenyei György Könyvkiadó, Nyíregyháza, 121 + 16 p.

SZARKA, L. (2010). *Szempontok az úgynevezett megújuló energiafajták lehetőségeinek és környezeti hatásainak összehasonlításához.* In: ÁDÁM, J. – SZABADOS, L. *Megújuló energiaforrások és környezeti hatások.* – Magyar Tudomány 171(8), pp. 979–989