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INCREASING ROLE OF RENEWABLE ENERGIES IN THE MAINTENANCE OF SETTLEMENTS IN EASTERN HUNGARY

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Abstract

The most important issues of the new millennium are the adaption of renewable energies; and the establishment and operation of social and technical systems that have little impact on the environment. People must undertake to solve this problem during the establishment of the everyday life of the settlements. In the course of this study, the authors surveyed the documents related to the energy strategy of the local municipalities of the Northern Great Plain region. This document analysis was supplemented by interviews. Finally foreign and Hungarian case studies were analyzed, based on the literature, self-collected data and interviews. The paper presents the good practices for sustainable settlement development based on renewable energies.

Key words: development strategies, renewable energies, sustainable settlement

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1. Introduction

One of today's key issues is the adoption of renewable energy source and the establishment and operation of social and technical systems that have small impact on the environment (Peiro-Signes et al., 2013; Vikolainen et al., 2013). People must undertake to solve this problem during the establishment of everyday life of the settlements (Herghiligiu et al., 2013).

From this aspect, settlements have a dual role. On the one hand, as a constructed and technical system, a settlement has one of the most significant effects on the ecosystem – either to the cycle of energy or other Earth systems. On the other hand, a settlement has a prominent role in the life and the regulation of the local community and in the shaping of the actions of its members (Reisinger, 2012; Walker et al., 2010).

Therefore, without the analysis of the role of municipalities, it is not possible to feature an accurate model of the energy strategy and to provide recommendation on the spread of renewable energy sources and energy-efficient building systems (Dvarioniene, 2013). In this manner, the importance of this research is supported by the following facts.

First, the local municipalities are directly connected to the local population, and studying the latter target group is often easier through the local authorities. Second, the city-scale development and application of renewable energy systems is inconceivable without the involvement of local municipalities (Scott and O'Neill, 2013; Taranu, 2012).

Hungary's settlement pool has a total of 3,152 towns and villages (CSO, 2013) and approximately 600 settlements with multiple disadvantages, which are rooted in complex causes. These disadvantages include acute employment crises, high unemployment rates, lack of enterprises, unavailability of proper infrastructure, large distances from settlements functioning as regional centers, and

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poor accessibility that brings them into external or internal peripheral situations. These disadvantages result in low incomes and the emergence of social problems, poverty, emigration and aging populations, thereby leaving wrecked societies behind. Because of the low levels of incomes in such settlements, the conditions of public facilities tend to deteriorate in these settlements, the obsolescence of the facilities and infrastructure becomes apparent, and the costs of upkeep consistently rise and are borne as increasingly heavy burdens, which makes the operation of the local governments unsustainable without external aid. The upkeep of settlements and the consolidation of the debt trap caused by considerable amounts of loans spent on normal operations are shouldered by the state and consequently the society, as material burdens.

However, the funding of the upkeep of settlement institutions is a major challenge, not only for settlements with multiple disadvantages (and mostly small populations) but also prospering towns with more inhabitants and higher incomes because such financing takes substantial funds away from settlement development tasks.

One potential way out of this situation, which is appears to be applicable to Hungary as a whole, can be the satisfaction of the energy demands of settlements and the generation of income streams for the local governments and populations with the utilization of locally available renewable energy sources. Such implementation of renewable energy sources would have better prospects if the government supported the introduction of the compulsory feed-in system for heat and electricity produced from renewable and alternative energy sources (METÁR), which has been deferred since 1 January 2013. Currently, the advantage of using renewable energy sources lies in the savings that can be achieved in the form of energy that is replaced, which clearly is a significant aspect.

2. Materials and methods

In the course of the research, we surveyed the documents related to the energy strategy of the local municipalities of the Northern Great Plain region. By the analysis of these materials, we determined to what extent the role that the application of sustainable energy resources plays in these settlements.

The document analysis was supplemented by interviews. These interviews involved discussions with those stakeholders who are interested in the urban development of 14 municipalities about the function of renewable energy sources in the operation of settlements.

Finally, we analyzed foreign and Hungarian case studies based on the literature, self-collected data and interviews. These case studies were selected to present examples of the initial steps towards the direction of the energy self-sufficiency.

3. Settlement development plans and strategies

Sustainable development has significant importance in the strategic framework of the EU. This framework is supported by a number of community initiatives and the binding laws. Within the framework, the energy management has essential importance because it affects not only air pollution emissions but also trade policy, employment policy and agriculture (Shirley and Kammen, 2012; Sperling and Möller, 2012). Local governments play an important role in determining the amount of energy consumption, not only directly (through the energy consumption of the local government institutions, the public lighting and the fleet) but also through exercising influence on the residents, local enterprises and companies, and even tourists; the local government can further efforts to achieve sustainable energy management.

The significant role of municipalities in implementing sustainable energy management makes it interesting to study how the municipalities in their strategic developmental documents evaluate, control and use the opportunities related to renewable energy sources.

We studied the developmental documents implemented by the municipalities of Northern Great Plain Region. On the one hand, these are settlement development concepts and programs; on the other hand, these are forms of sector-specific documents. The majority of the studied settlements have a developmental concept. These developmental documents were created mainly after the EU accession because the allocation of financial resources could only occur on the basis of these documents. It seems to be clear that the municipalities over 5,000 inhabitants have development programs, while below this population size, we could rarely find a document to study. As a result we obtained less information regarding the smaller settlements. However, regarding the use of renewable energy sources, (and energy efficiency, to a lesser extent), the villages and small towns are the model areas of the development projects.

Because there is less demand for energy in villages and small towns, it is easier to satisfy the energy demand of these settlements with renewable energy sources, which have lower energy density. In the larger settlements of the region (with populations of over 20 thousand), we could found sectoral strategies for the implementation of renewable energy sources. However, to what extent these strategies affect the scope of the renewable energy sources depends on the attitude and interest of the local decision-makers.

No correlation was observed among the size of settlements, the geographical location and the number of strategies that address renewable energy sources. Most (87%) of the current urban and regional development planning documents address or mention the issue of energy management. It is clear that the younger the document is, the more pertinent the issue of energy management.

The rate of mentioning the issue of renewable energy in these planning documents is slightly lower (65%); however, even the rate means that, in addition to job creation, infrastructure development and the general issues of environmental protection, renewable energy is among the most mentioned aspects to develop. In most cases, in addition to the environmental aspect, the impacts on the living conditions and on the socio-economic structure of the settlement are highlighted.

In the sectoral documents, the frequency of mentioning renewable energy primarily depends on the topic of the document. The environment-related strategies all mentioned the increase of the use of renewable energy sources as a priority. At the same time, it is clear that the passages mentioning of the issue of renewable energy sources appear principally due to the phasing in of the EU and national level documents - at least at the settlement level. This transition often involved the mechanical takeover of objectives and guidelines, rather than to adapt them to the local conditions. In contrast, less than half (45%) of the economic documents mentioned renewable energy sources.

These documents often mention the assets related to renewable energy and manufacturing possibilities of the related equipment. All transportation strategies emphasize the significance of energy savings and the need to improve energy efficiency; in certain documents, concrete proposals are formulated.

Regarding the specific objectives, not surprisingly, the issue is mentioned apropos of "energy saving", "improving energy efficiency", "increasing the use of renewable energy" and "reducing the effects of climate change". Two municipalities of the region (Hajdúszoboszló and Martfű) are highlighted because, due to EU-funded projects, a Sustainable Energy Action Plan (SEAP) was in each of these municipalities. These documents provide guidance that follows a specific intervention logic for the companies operating in the towns and for the local population, and assigned the duties of the government as well.

Therefore, during the planning of the settlements' future, the settlements of the Northern Great Plain region placed greater emphasis on the issues of energy efficiency with the primary objective of increasing the use of renewable energy sources.

4. The opinion of the local leaders

The role of the renewable energy in the life of the settlements is significantly affected by the issues of the personal attitudes. After the analysis of the documents, it became clear that the issue of incorporating renewable energy into the vision of the settlement, regardless of size and position, depends on other personal factors. Therefore, during the conducted interviews, we inquired about the opinions of the local leaders (mayors, office workers, and local entrepreneurs) regarding the potential and significance of renewable energy development.

Among the selected settlements, some have already implemented energy efficiency-enhancing developments (10 settlements); however, some of the rest of them had not previously included this objective into their development plans.

The answers clearly indicated that one of the main motivating factors of renewable energy development is the reduction of the operating costs of the settlement, and the other is the objective of urban planning related to settlement rehabilitation. In the latter, the implementation of energy efficient systems, which use renewable energy, were mentioned; in connection with abandoned areas, the exploration of certain parts of forests and the rehabilitation of the degraded parts of the settlement were mentioned.

The positive experiences of the previously implemented renewable energy projects were also mentioned as a motivating factor. In those settlements where such projects were implemented, or had regarding such projects, unequivocally, more ideas arose, and renewable energy projects considered a more important issue in the life of the settlement. In most cases, the energy efficient transformation of the heating and the lighting of public buildings were mentioned as a development opportunity by the respondents.

In connection with this issue of energy efficiency, the improvement of systems also could be mentioned because everyone is familiar with the solution in the complex transformation of buildings (e.g., insulation, replacement of windows, heating system modernization, and space-saving task organization). The respondents thought that it is not sufficient to replace the previous heating system.

The energetic development of transportation systems also arose in the case of larger settlements, along with its restructuring by rationalization. In addition to these cost reducing factors, several respondents also mentioned the possibility to generate income. Regarding income generation, the natural features and utilization opportunities of the buildings that are managed by the municipalities were highlighted, which enables the opportunity to produce energy. The energy generated in excess of the needs would clearly contribute to increasing the income of the settlement. These options were mentioned in particular by the representatives of the smaller settlements.

In the case of the possible developments, the complex management of the investments also appeared: every interviewee mentioned that they expect job creating and economic stimulus effects from the development of renewable energy projects. In addition to these effects and the potential savings opportunities, the adequate support system and the expansion of knowledge were clearly indicated as the pledge to stimulate the investments that aimed to improve energy efficiency.

The documents and the interviews with the leaders also indicated that successful examples play an important role in the decisions of the local authorities regarding energy efficiency.

5. Examples of settlement development planning based on the renewable energy in Eastern Hungary

In this research, foreign and Hungarian case studies are presented to examine how locally available renewable energy sources can be deployed to reduce the upkeep costs of settlements while increasing their incomes. An example to be followed has been set by Wildpoldsried in Germany, which is a remarkable case of energy self-supply and of the generation of funds in settlements. This example is followed by the cases of two settlements of similar populations in northeastern Hungary that have been chosen for their particularly disadvantaged situations and their attempts to form new destinies with the use of renewable energies. Finally, two small towns and a medium-sized town efficiently utilizing the hydrogeological endowments of Hungary and operating geothermal systems in their own areas are presented.

5.1. Renewable energy generation system in the settlement of Wildpoldsried

Wildpoldsried is a settlement of 2,500 people in the southern part of the federal state of Bavaria, Germany (Landkreis Oberallgäu) (Fig. 1). Until 1997, Wildpoldsried was a declining settlement struggling with emigration and debts, which are problems that were to be tackled by the new mayor and general meeting of the municipality. In this context, the local government aspired to take steps to rely on locally available renewable energy sources to a maximum extent. In 2010, the local government produced 20,543 MWh of electrical energy, while they consumed only 6,391 MWh.

The municipality further sought to cover its energy demands fully using renewable energy sources. Having reached 300% electric power production, they now have the intention to acieve the same level in the fields of heat and transport energy by 2020. In addition to the local government, the population is also involved in renewable energy production, with the generated energy being directly fed into the grid to earn incomes, which amounted to EUR 4 million in 2010.

The Wildpoldsried renewable energy system can be described as a combined renewable energy production system, meaning that they utilize all the locally available and exploitable renewable energy sources. In the area of the settlement, there are three mini power plants, four biogas plants in the animal farms (one was under development in 2010), the solar panel systems of community buildings that have been extended to 9 further buildings since 2009, as well as 190 private solar panel systems operated by the individual households. The heat demands of public buildings in the village are covered by a district heating system fueled with biogas and wood pellets, supplying 42 buildings with heat energy; furthermore, there are seven wind turbines erected in the surroundings of the settlement with 2 others being under construction (2010) (Allen, 2011).

The environmental consequences of the eco-energy management represented by this settlement are considerable: in 2010 alone, the use of renewable energy sources rendered useless 220,000 liters of fuel oil, and therefore, 600,000 kg less CO_2 was emitted into the atmosphere.

In addition to the above-described future plans, the settlement participates in various pilot projects involving electric car and bicycle sharing systems, smart grids and energy storage solutions (Jopp 2012; Wittmann 2012; Woldt-Fichtner, 2009).

Germany has the long-term objective to cover most of her electric power generation – 25% by 2020 and 80% by 2050 – using renewable energy sources. The development of renewable energy production and innovation is supported by all available means (legislation, market regulation, energy storage facilities nation-wide, and e-mobility) along with the development of differentiated production and distribution systems (development of smart grids); until 2020, the country intends to expend approximately EUR 200 billion to accomplish these objectives (Rajgor, 2012).

5.2. Renewable energy elements in the model economic system of the Municipality of Döge

The method applied in Wildpoldsried can also be implemented in Hungary because the necessary environmental endowments are in place in settlements that otherwise have rather poor funding opportunities for their multiple disadvantages. Although on a somewhat smaller scale, the same path was chosen by Döge in Szabolcs-Szatmár-Bereg County (Fig. 2) and its 2,200 inhabitants. The settlement has a small number of production plants with a high unemployment rate, while the revenues of the local government are restricted. Development potentials lie only in grant funds, the public works program and the maximum utilization of local resources. When these facilities are well managed, however, the possible solutions to the difficult situation become apparent. Here again, the quest for feasible solutions was headed by the mayor and the general meeting of the municipality, who during 2010–2014 made substantial achievements. The results are comprised of three constituents: energy modernization and the utilization of local renewable energy, modernization and development of the water-borne and municipal transport infrastructure, and agricultural production.

The first step of the energy modernization development was the conversion of the granary of the former manor, which also had its architectural values, into a youth center; indoors, the building was fully insulated, and the sanitary hot water supply was converted to a solar heating system. The second step was the energy-related modernization of the seat of the local government, which accommodates several institutions. In the first phase of this project, the insulation of the boundary walls, the replacement of doors and windows and the construction of the rainwater utilization system were implemented. Currently, in cooperation with the neighbouring kindergarten, a heat-pump type heating system is under construction with its electric power demand to be partially covered by a solar panel system.

The third step is the utilization of biomass, in which the twigs that are useless for the local forestry management, as well as the continuously regenerating, young locust trees by the side of the agricultural roads managed by the municipality, are chopped and baled, and then used for heat generation in the biomass boiler installed in the healthcare institution of the local government (originally fueled with wood pellets). Moreover, the baled wood chips are also used for social purposes, i.e., the fuel demands of households can be satisfied at affordable prices.

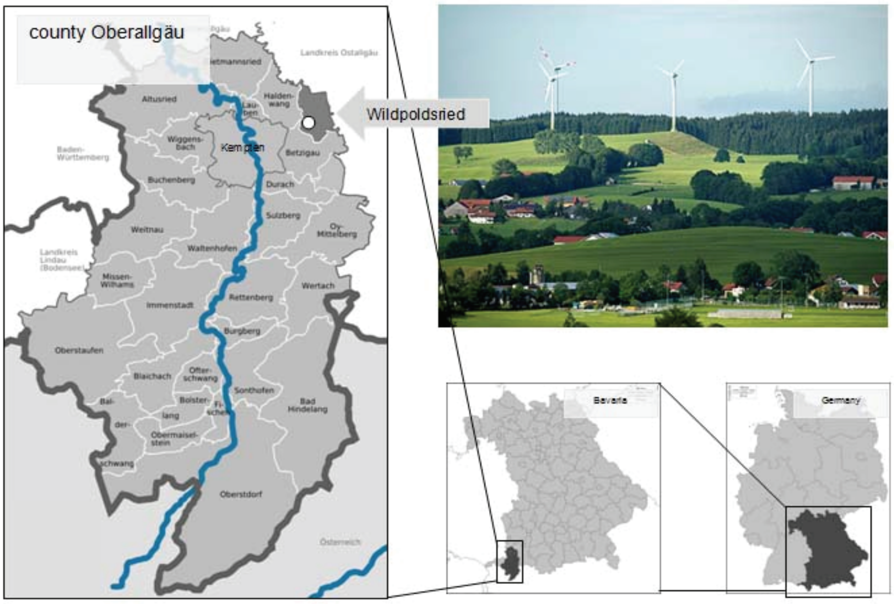

Fig. 1. Renewable energy generation system in the settlement of Wildpoldsried, southern part of Bavaria (Source: own work)

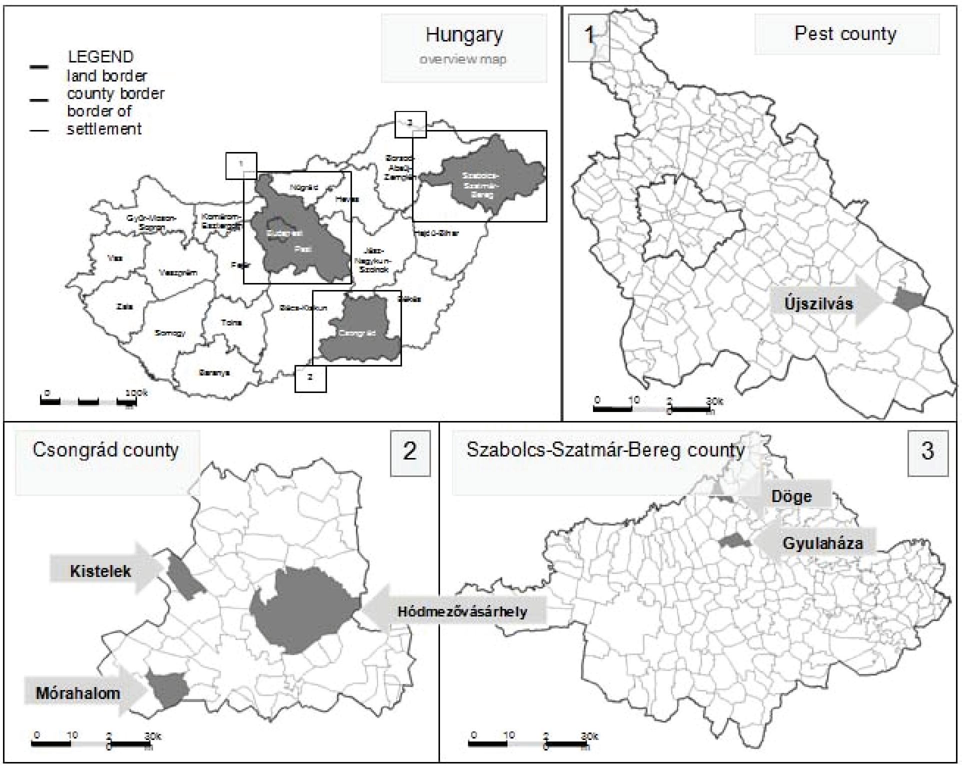

Fig. 2. Geographic locations of the case studies in Pest, Csongrád and Szabolcs-Szatmár-Bereg counties

With these measures, the local government has achieved substantial savings in energy and costs, while cutting hazardous material emission. In addition, the now unutilized and generated financial funds are expended on further renewable energy developments.

5.3. Renewable energy system of the institutions of the Municipality of Gyulaháza

Also situated in Szabolcs-Szatmár-Bereg county, Gyulaháza can be found to the south of Kisvárda (Fig. 2*)* with a population of 1900. The mayor of the settlement – who has been leading this village in the Szabolcs region for 38 years now – believes in a consistent process of building the settlement from its own resources.

During the recent decades, he has created an enterprising, income-generating local government, where the emphasis falls on the infrastructure facilities that support sports, recreation and active leisure-time activities. Primarily, it is the youth teams of sports clubs that prefer organizing training camps in the settlement. The electric power and sanitary hot water demands of the buildings where the associated services are provided (sports hall, swimming pool, accommodation units, and school) are satisfied by the country's largest solar cell and solar collector surface installed on a public building.

For the implementation of the facilities, grant application resources and labor employed in the framework of public works were used, and therefore, the investment costs of the buildings proved to be just a fraction of the values quoted for the construction works at the public procurement procedure. Due to the applied renewable energy systems and generated incomes, their operation is sustainable and ensures sufficient revenues for the settlement to realize its future plans.

5.4. Geothermal system of the settlement of Kistelek

Lying 30 kilometers to the north of Szeged, Kistelek *(*Fig. 2*)*, a settlement of 7,100 inhabitants, established a district heat supply system based on geothermal energy for the settlement in the period from 2004 to 2007 to supply heat, sanitary hot water and bathing water for municipal and regional institutions.

Used as the heat-carrying medium, thermal water is produced and then returned to the water-bearing layer by a thermal water well pair consisting of a 2,095-meter deep production well and 1,700-meter deep reinjection well. The 82 °C thermal water of the production well reaches the surface with a yield of 90 m^3/h.

The total 2 MW of heat output is transferred to the 9 supplied institutions via a 6-km long pipeline, and then the heat energy is transmitted via heat exchangers. The system is fully automated, and the returning 40 °C water has an additional heat output reserve of 2 MW, which, in the future, can act as the heat supply of public institutions, a block of flats, horticultural establishments and a projected thermal village.

The total cost of the investment was HUF 530 million, and it was implemented with the support of the Environmental and Infrastructure Operational Program (KIOP) and from the resources of settlement. As a result of the investment, the institutions have achieved 10% savings on energy costs and 70% savings on heating, and on the basis of these figures, the payback period will be 15 years. As an indirect consequence of the reduction of the operating costs of the public institutions, employment has remained sustainable, and the competitiveness of the settlement has improved. The harmful material emissions of the region have reduced to 1.38 kt p.a. for CO_2, 23.28 kg p.a. for CO and 66.25 kg p.a. for NO_x. With respect to community targets, the national amount of renewable energy use has increased to 31.25 TJ p.a., and therefore, its rate has risen from 3.5% to 3.6% (Szanyi-Kovács, 2010*)*.

5.5. Geothermal cascade system of Mórahalom

In Mórahalom, which is inhabited by more than 5,800 people at the southeastern border of Hungary (Fig. 2), an integrated geothermal heat utilization system was constructed to use the heat energy of the thermal water with reliance on different technologies by connecting consumers of various heat demands, while the temperature of the thermal water gradually decreases.

The total cost of the investment was HUF 526 million, including the establishment – similar to the facilities of Kistelek – of a 1,260-meter deep production well of 70 °C effluent water temperature and a 900-meter deep reinjection well.

Transferred via heat exchangers, the heat of the thermal water supplies energy to 8 institutions, and therefore, annually HUF 40 million savings can be achieved.

The high methane content in the water of the production well is used for driving a gas engine, and therefore, the electric power demand of the thermal water production system is covered from an energy source associated with geothermal energy (remark: in the past, the gas contents of thermal waters used to be released to the atmosphere with the use of gas separators).

With the application of reinjection – in view of their otherwise very slow refilling – thermal water reserves regarded to be fossil sources are exploited in a sustainable manner, while due to the fully closed water circuits, the protection of the subsurface water reserves and the water quality of the water bodies can be ensured. Furthermore, thermal water, which does not come into contact with the environment on the surface because it is not transferred to any above-ground recipient, does not impact the living world with its high mineral contents.

The environmental benefits of the system are enhanced by an 80% decrease of harmful emission, the annually replacement 481,907 m^3 natural gas, the decrease of 866.45 tons less CO_2 emission, as well as the reduced CO and NO_x emission (Szanyi-Kovács, 2010).

5.6. Geothermal public utility system for integrated heat utilization in Hódmezővásárhely

As a city of county rank and with more than 45,000 inhabitants, Hódmezővásárhely is the second most populous settlement in Csongrád County (Fig. 2) and can be regarded to have set the absolute standard for municipal geothermal systems. The goals of the series of investments made in Hódmezővásárhely was to 1) replace sanitary hot water produced from cold drinking water with the use of natural gas by extracting 45–50 °C thermal water from the Upper Pannonian layers at approximately 1,000 meters in the local district heating system and 2) to use the heat capacity of the 80–86°C fluid coming from a depth of 2000 meters for the replacement of heating also based on natural gas in the municipal heating system. The four separate, unconnected district heating systems supply blocks of flats, public institutions, public baths and indoor swimming pools. For sustainability, the cooled down thermal water is reinjected at 3–4 bars in regions near the layers of exploration; the underlying technology was first applied here cost-efficiently back in 1998.

Currently, 10 thermal wells are operated, that is, eight production and two reinjection wells; in addition three further wells – with medicinal water qualification – serve balneological purposes. The system was constructed in subsequent phases (1967, 1984, 1994–1998, 2007), and currently, it covers the heating and sanitary hot water demands of 2,725 apartments and 130 institutional consumers, featuring a combined heated volume of 723,835 m^3.

The annual volume of exploited and utilized sanitary hot water is 150,000 m^3, and the exploited heat energy amounts to 19,000 GJ a year. The reduced prime cost of sanitary hot water is 70–80 HUF/m^3 (instead of 500–600 HUF/m^3 via fossil-fuel based energy), the volume of thermal water exploited for heating is 880,000 m^3 p.a., the reinjected volume is 400,000 m^3, and the heat quantity of the supplied thermal heating is 105,000 GJ a year.

The reduced prime cost of the generation of thermal energy for heating – including the costs of reinjection – is 750–850 HUF/GJ, while for the conventional technology based on natural gas, the cost is 2,800–3,000 HUF/GJ. The environmental effects of the geothermal system are outstanding because annually, it replaces the consumption of some 4,050,000 m^3 of natural gas, thereby reducing CO_2 emissions by 7,000 tons. With good and circumspect reinjection practices, the system can be sustained in the long term. The investments were implemented with the involvement of governmental, local governmental, and European Union (Environment and Energy Operational Program, KEOP) funds with a payback period of six years and an anticipated lifetime of 50 to 100 years. In comparison with conventional district heating services based on natural gas, 50% cost savings can be achieved.

5.7. Combined municipal renewable energy supply system in Újszilvás

In Pest County, Újszilvás (Fig. 2) saw the construction of a heat-pump geothermal municipal heating system in 2010, followed by an electric power generation site, which is considered as Hungary's largest solar power plant in 2011, order to satisfy the local electric power demands.

The Municipality of Újszilvás Village, with a population of more than 2,600, set out to realize the modernization of the heating systems and sanitary hot water supply of public institutions from 208 to 2010 to reduce upkeep costs and drive more environmentally conscious operations. To this end, the local hydro-geological endowments were exploited to implement a geothermal system based on shallow layers. The starting point was the necessity to modernize the waterworks for local water supply, during which the option to utilize wells of high effluent temperature – in addition to regular water supply – for geothermal purposes was considered in 2005. In 2008, with reliance on financing from the Norway Grants, a pair of production and reinjection wells was established, with a bottom depth of 400–450 meters and filtering depth between 350 meters and 400 meters.

With the application of a heat pump, the 30–32 °C water of the production well allowed for a heat supply to public institutions in a system where 1/5–1/6 electric power was to be expended, and the water required heating to increase the temperature by 10–15°C to produce 40–50°C water. In five public institutions i.e., the school, kindergarten, library, mayor's office, sports hall and community center, this heat-pump provides for heating in the winter and cooling in the summer. The mayor's office and the kindergarten have heating systems combining radiators and fan-coil units, whereas the heating systems of the community center and the school feature radiators and unit heaters. In the first heating season, approximately 53.4% energy saving was achieved.

To reduce the upkeep costs of the settlement further, while satisfying the electric power demands of the heat-pump system and other local consumers, in 2010 and 2011 additional, locally available renewable energy sources were deployed for municipal energy supply. One of the disadvantages of heat-pump systems is the increased electric power consumption needed for operation. Within the framework of the Central Hungarian Operational Program (KMOP), a solar tracking, photovoltaic electric power generation system of 400 kWp output was established that – under the local climatic conditions (sunshine duration: 2,100–2,300 hours) – is capable of producing 630,000 kWh electric power annually.

The total cost of the investment, which was funded from Hungarian and European, as well as local funds in the ratio of 70% to 30%, was more than EUR 2.2 million (2010). The power plant erected in the outer area of the settlement is comprised of 1,632 solar cells on 68 frames that are equipped with a rotating system. The inverters convert the direct voltage arriving from the direction of the solar cell into 240 V alternating voltage of 50 Hz frequency, and the power is transmitted to the network of the universal supplier. This renewable energy source is suitable for satisfying the electric power demands of municipal geothermal heating system constructed earlier, public institutions and public lighting, while it moderates environmental loading and serves as the basis of the practical training base of several institutions of higher education (University of Szeged, College of Szolnok, Szent István University).

The combined municipal renewable energy system of Újszilvás demonstrates an exemplary technical solution that concurrently provides for the heating and cooling, water supply and electric power demands of public institutions.

6. Conclusions

Among the settlements of the Northern Great Plain Region, the issues of increasing energy efficiency and reducing energy costs became important. This importance was clearly demonstrated by the development strategies that also highlighted this topic. However, renewable energy is primarily regarded by the stakeholders of the settlements as a "tool" to reduce the operational costs.

Nevertheless, in the case of small settlements, we found a number of examples of the implementation of renewable energy projects in Eastern Hungary (Döge, Gyulaháza, Újszilvás), mainly based on the geothermal capability. These examples, primarily due to their complex solutions, are not only conducive to local self-sufficiency but also highlight that developments of the settlements should be based on renewable energy sources; the key to such renewable energy developments is the development of community energy systems, as adapted to local conditions, which is confirmed by the example of Wildpoldsried in Germany.

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