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ECONOMIES OF SCALE VEGETABLE FORCING THE UTILIZATION OF GEOTHERMAL ENERGY

TÉGLA, ZSOLT

Summary

One of the highest costs of vegetable forcing is energy including heating energy, whose rate can reach up to 25-35% of the total production costs. Our dependence on the import of fossil energy puts enterprises involved in vegetable forcing into a vulnerable position. With the utilization of domestic green energy and thermal energy this dependence could significantly be reduced. Hungary's geothermal features in the region are excellent, the energetic utilisation of thermal water is suitable for heating modern horticulture greenhouses. However, due to the high investment costs primarily economies of scale plants are viable, which are also economical to operate from a logistical point of view. Hydroculture vegetable forcing offers excellent employment opportunities, allowing continuous employment, while permitting high incomes in proportion to farm size and revenue – owing to the technological intensity and the characteristics of the products.

Considering the criteria of economies of scale vegetable forcing it can be stated that it is mainly 3 and 5 -hectare size farms heated with geothermal energy that are able to achieve a level of operating profit which can safely form the basis of the development of integrated hydroculture vegetable forcing. However, because of the high investment costs of the greenhouse and the geothermal wells and the technological intensity the investment/financial as well as the operational/production risks of these farms increase dramatically. Examining these risks is a key issue for future large greenhouse and geothermal investments.

The problems expressed by the experts concerned the outdated greenhouses that act as barriers to increase earnings. The success of production is mainly determined by the climate during vegetable forcing. The prerequisite for this is to apply the proper cultivation apparatus which meets the requirements of the 21st century.

Keywords: *renewable energy sources, competitiveness, economy of scale, geothermal energy*

Jel Cod: *L23, O13, Q42*

Introduction

The potential geothermal features and characteristics of Hungary

In 2009 the European Parliament and the member states agreed that by 2020 approximately 20 per cent of the gross final energy consumption should be covered by renewable energy. Some countries, such as Austria which has abundant and cheap natural resources (e.g. hydro energy), can generate more power from renewable sources (30%) than those countries where there are few renewable energy sources (e.g. the Netherlands, 4.3%). The proportion of renewable energy is the highest in Sweden currently it stands at 46.8%. In harmony with the Directive Hungary must increase its renewable energy utilization from the current 4.3% to 13% by 2020 within its gross energy consumption (Eurostat, 2013).

The most important renewable energy source in Hungary is biomass, which is the source of 80 percent of renewable based production. No significant progress has been made in geothermal energy use. However, the advancement of a country like Hungary with its geopolitical and natural endowments largely depends on how it can replace and sustainably operate the existing economic model based on traditional (fossil) energy sources with an alternative economic model relying on green technologies.

In Hungary the geothermal gradient, which shows how many ºC the temperature increases by units of depth intervals, is an average of 5°C/100 m, which is about one and a half times higher than the world average. The reason for this is that the crust in the Pannonian Basin, which includes Hungary, is thinner than the 30-35 km world average – only 24-26 km; the other reason is that this Basin is filled with sediments with excellent insulating properties (clays, sands). The measured heat flow values – that is the heat discharged from the depths of the earth per unit area – are large (around 90 mW/m^2), while the average of this value in the European continent is 60 mW/m^2. The mean temperature is approximately 10ºC on the surface of the country. According to the above mentioned geothermal gradient the temperature of the rocks and water at 1 km is 60 °C while at a depth of 2 km it reaches 110ºC (Liebe, 2006).

The geothermal gradient in South West Hungary and in the Great Plain is higher than the national average while in the Small Plain and in the mountainous areas it is lower. The upcoming water cools along the thermal well tubing, therefore the temperature of the surfacing water rarely exceeds 100ºC. Steam occurs only at a few, currently not sufficiently explored deep wells. In Hungary wells of 30ºC or warmer outflow are considered thermal water wells or thermal springs. Thermal water exploration is possible in about three-quarters of the country (Figure 1).

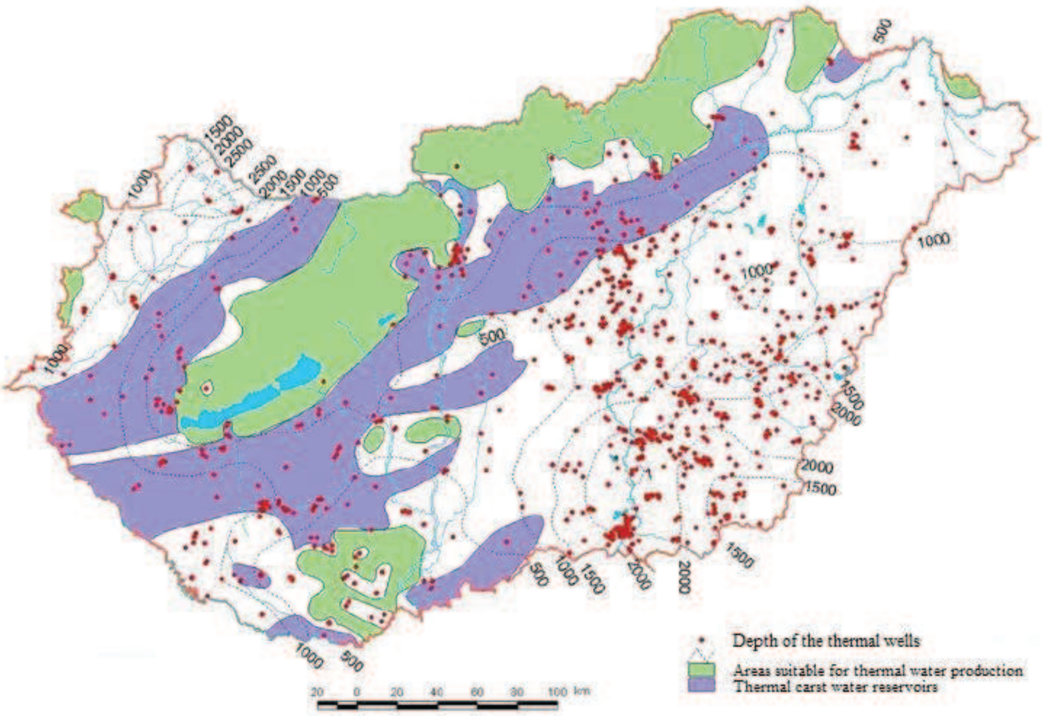

Figure 1: Regional distribution of areas suitable for geothermal exploration and geothermal wells in Hungary

Source: Ministry of Environment and Water (2006)

The significant pressure decrease triggered by thermal water production from the warm water reservoir formations of the basin stopped or diminished in most areas in the 1980's. Although our information on thermal water production is incomplete, the reduction of the pressure drop is attributable to the decreases mining activity on the basis of the not wholly reliable data. Of the 1400 thermal wells in Hungary 900 are in operation, daily water extraction amount to almost 0.2 million m^3. Approximately 30% of the thermal water wells serve balneological purposes, more than a quarter of them provide drinking water, and less than half of them are used for geothermal energy recovery purposes. In the future thermal water extraction for geothermal energy recovery purposes must not be allowed without a recharge, the cooled thermal waters must be pumped back into the thermal water bearing layer (Figure 2).

In the case of geothermal energy the costs of the heat supply and heat distribution system must be added to the direct cost of wells and reinjection therefore funding can be the major hindering factor (Ministry of National Development, 2010). According to the National Action Plan (NFM, 2013) the planned use of geothermal energy can primarily be the production of heat energy. These include, in addition to the heating of horticultural constructions, the residential buildings owned by public institutions and local governments. The exploitation of geothermal energy for heating could rise threefold by 2020.
With the termination/deadline extension of reinjection obligations the current practice for the storage of already utilised thermal water is letting it into surface water after a temporary storage in a cooling pond. The development of the number of thermal wells used for geothermal energy recovery purposes is shown in Table 1.

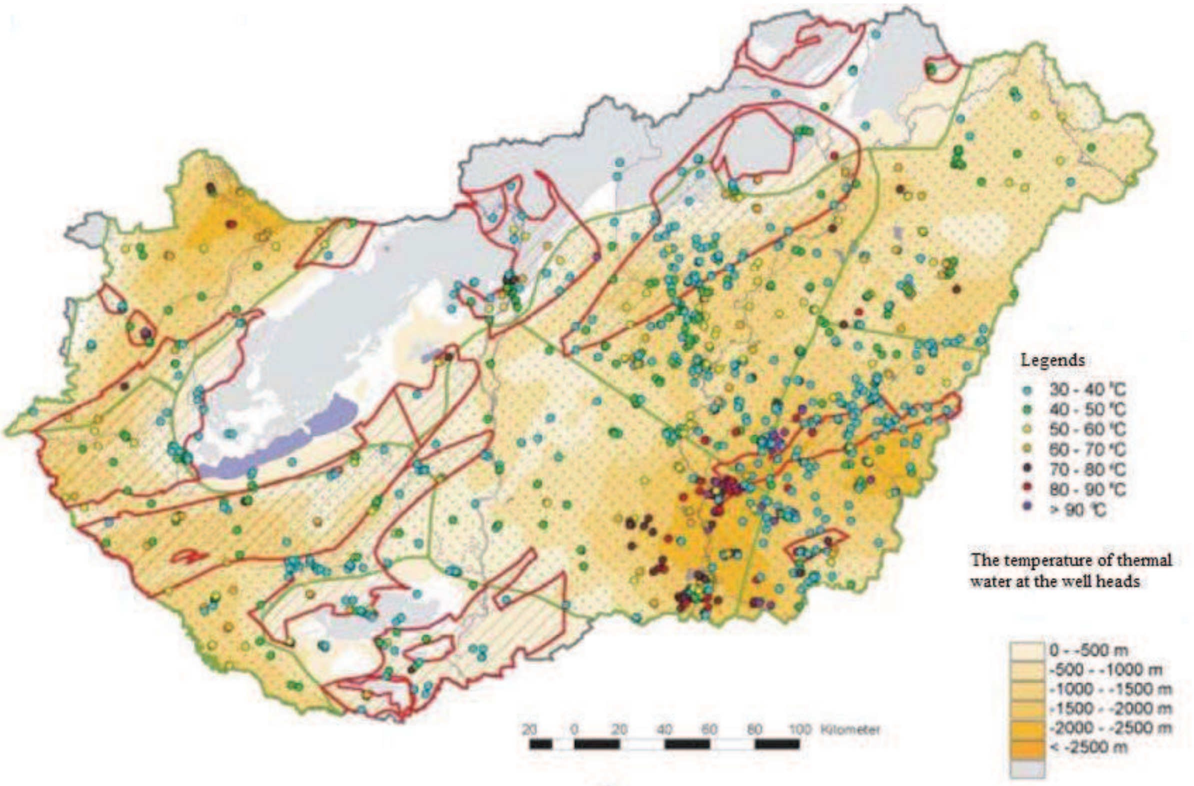

Figure 2: Thermal water wells and their water temperature in Hungary
Source: Ministry of Environment and Water (2006)

Table 1: The number of thermal wells used for geothermal energy recovery purposes by counties between 2008 and 2012

County	Number of operating thermal wells				
	2008	2009	2010	2011	2012
Bács-Kiskun	4	4	4	6	8
Baranya	3	3	3	4	4
Békés	3	4	4	7	7
Borsod-Abaúj-Zemplén	2	2	2	2	2
Budapest	1	1	2	1	1
Csongrád	87	86	92	110	113
Fejér	-	-	1	1	1
Győr-Moson-Sopron	3	2	2	2	2
Hajdú-Bihar	1	1	1	1	1
Jász-Nagykun-Szolnok	7	7	7	9	9
Komárom-Esztergom	1	1	1	1	1
Pest	1	1	1	3	3
Somogy	-	-	-	-	1
Vas	1	1	1	1	1
Zala	1	1	1	1	1
Total	**115**	**114**	**122**	**149**	**155**

Source: Hungarian Office for Mining and Geology (2013)

In summary it can be said that Hungary has fairly favourable conditions for geothermal energy. Thermal water without reinjection permits very low heating costs only in those horticultural farms where there are already existing thermal wells therefore it is important to develop these farms in the future. In the case of newly drilled wells it is perceptible that investment cost can be decisive mainly for larger areas or residential communal heating systems. There are numerous examples in the Southern Great Plains: Hódmezővásárhely, Szeged, Szentes, and Szarvas, etc.

The development of the farm size of vegetable forcing

In the case of the Netherlands and Belgium, the two countries that play a major role in Europe in this respect, the technology is highly advanced in vegetable forcing, which is a result of 50 years of continuous development. The rising costs justified the increase in farm size and the related automation. In these countries the steadily increasing proportion of artificially-lit areas can be observed. Unlike Spain the Netherlands has a huge competitive advantage in relation to transport costs, because it is situated in the middle of a nearly 250-million community. The major problem is the cost of labour, which can reach 15-16 euros per hour, which may amount to 30-35% of the production costs. As a result, in the long run only the fully automated farms can be competitive. In relation to the total cost land price, which can reach 40-80 euros per square metre, is significant. The land is as expensive as the greenhouse located on it, so investments can be accomplished with the help of 15-20 year bank loans. In the Netherlands 80% of sales is realised in supermarket and hypermarket networks and only 20% in traditional veilings. This latter type of sales reached its maximum in the 1980s and then its significance decreased gradually from 1986. The plant sizes have grown from 1-3 ha to 5-8 ha, but 50-hectare large-scale farms, established on many small production bases and working as private operations, are not exceptional either. In terms of cultivation it is observable that in the Netherlands and Belgium less producers work on larger farms. Bigger companies take over production. As a result of the company mergers the growing area per owner is now 3-50 hectares in size. Sales are well organized in the productions areas and cultivation is specifically organized in light of the market demand. The proportion of short crops/cultures is reducing, and focus is on the reduction of the production costs (mainly the amounts spent on heating and labour) (Tégla – Marselek, 2008; Tégla, 2009).

In the Netherlands the average size of a vegetable farm in the case of tomatoes is 5.1 hectares, for paprika it is 4.6 hectares and 2.5 hectares in the case of cucumbers per plant in 2014. Between 2000 and 2014 the largest increase in farm size was observed in the case of tomato forcing plants (CBI, 2014).

The most important vegetable forcing country in Southern Europe is Spain. About 30 years ago the region of Almeria in Spain began to develop a unique horticultural production system. The "Almeria model" is based on the intensive use of inputs in the plentiful Andalusian sunshine, in plastic structure greenhouses. Over the years, 35 thousand ha of "plastic sea" growing area was developed in the region. High yields throughout the year, and stable markets in Northern Europe brought prosperity to Europe’s once poorest region. Changes in consumer demand make it untenable to continue production based on the classical model. Intensive agriculture is subject to a number of pest attacks. Intensive horticulture in warm areas and enclosed spaces attract insect pests as well as plant infections that should be avoided. However, consumers are increasingly concerned about the possible health effects of the chemicals, even if these chemicals are required because of the insects and their amount is considered negligible. As a result, this extremely effective and intensive production system is no longer presentable in major import markets. The products from Almerian greenhouses are often rejected in the main European markets. A further additional step is necessary: the introduction of a new technology such as biological insect protection may require the complete modernization of the production system. The use of labour and other inputs as well as also structure of the greenhouses could be seriously affected. This will have an impact on the economies of scale, which is steadily increasing in line with European trends (Merino – Pacheco, 2012).

The modern greenhouse tomato production sector of the USA began to develop in the north eastern states near the major urban centres. In the 90's intensive greenhouse construction was started, and observable migration started into the south western states. This triggered observable changes in the size of the greenhouses since the new investment reached or even exceeded 10 hectares. The new facilities resulted in technological renewal such as huge glass panels and taller structures (Mathias, 2012).

According to Nederhoff (2012), vegetable forcing significantly increased and became more professional in New Zealand. Huge 'hi-tech' greenhouse complexes achieve good levels of production and high quality. On the revenue side, vegetable prices barely kept pace with inflation. On the other hand, production costs have increased dramatically. This is the case, e.g. with energy, or when complying with industrial safety and environmental laws and regulations. Significant cost savings can be realized only at the large-scale dimensions. This is confirmed by the fact that the number of producers of about 1200 12 years ago has dropped to around 500 by now and vegetable forcing plant size has increased considerably: 12 years ago there were hardly any greenhouses larger than 1 hectare, while today large complexes reach the size of 10 hectares.

In his article on vegetable forcing in South Korea H. Armstrong (2011) points out that after years of rapid growth the South Korean horticultural industry has arrived at a crossroads. The proximity to the Japanese market and the ability of diversification suggests that there are opportunities in the industry, especially if the government restores the system of subsidies. In the early and mid-90s vegetable forcing increased significantly, which attracted foreign investment owing also to government grants. The government plans to re-restore the system of subsidies in order to promote education and practical training, as well as to improve infrastructure and marketing. 30 to 50 hectare greenhouse groups with the necessary infrastructure are supported primarily. In return, state governments are expected to draw up clear plans including the development of infrastructure and marketing strategy; if this is adequately realised, the government funds 50% of the investment.

The larger the technological intensity of the vegetable forcing farm and thus the investment cost the greater the economic risk. However, there are other components of the risks such as production risk, market risk, personal risk, institutional risk and financial risk.

In respect of agricultural risks a number of authors (Kay and Edwards, 1994; Moschini and Hennessy, 2001) agree that in agriculture the production-, the market- (also known as price) and the financial risks are the most significant ones. Gabriel and Baker (1980) go further and distinguish business risk, which includes the production and market (price) risks and separately examined the financial risk.

According to Hardaker et al. (1997) the two most important types of risk in agriculture are the business risk and the financial risk. They mention, however, two other types of the business risks as well, which they call a personal and institutional risk, where the former refers to the risks of the person or persons operating the farm, while the latter refers to the uncertain effects of government measures on the producers.

Systems employing manual labour, including vegetable forcing, personal risk are a very important element.

The role of the personal factors in uncertainty is thus important and cannot to be overlooked. This statement holds true for decision-makers and their attitudes, personal interests, and motivations as well (Gyenge et al., 2015).

Simulation and the Fuzzy methods are becoming more common in the business planning and risk analysis of large infrastructural investment (Piros és Veres, 2013).

Material and method

In the course of my research I was driven by the objective to provide comprehensive, transparent and pragmatic models in order to be able to examine the effects of economies of scale and more specifically the heating systems on the operating profit in hydroculture vegetable forcing. The interviewees were experts who manage Hungary's leading vegetable forcing enterprises. These plants are competitive at the European level. They can provide technological, market, economic, and logistic data that can serve as a positive model for horticulturists involved in vegetable forcing.
The first round of data collection highlighted the importance of services closely related to production. I obtained the relevant information that enabled me to deepen my market, technical and legal knowledge from specialized professionals by means of interviews. My models, based on the facts listed above, were compiled on this basis.

The pre-formulated issues during the interviews were the following:

Issues of technology costs of the investment in vegetable forcing greenhouses:
- greenhouses (greenhouses, foil-covered plastic housings),
- boilers and controlling technology,
- machinery and equipment costs (water purification, warm mist vaporizer, farm truck, , production accounting systems, scales
- cost of intangible assets arising from investments,
- other preparation costs of the investment.

Issues of Cultivation Technology:
- price evolution of propagating materials, seedlings,
- biological pest control and cost,
- cost of protocol hygiene
- application technology of bumble bees that assist pollination, cost,
- pesticide use and costs,
- fertilizer and CO_2 use, costs,
- irrigation, water treatment costs,
- costs of other materials used in vegetable forcing.

Issues of heating and energy:
- amount and quality of fuel used, costs,
- determining the heating power needs, sizing of heating,
- environmental fines, contributions (with thermal water heating).

Issues of labour needs:
- annual evolution of labour demand and its characteristics,
- labour costs, contributions,
- changes in the performance of labour.

Issues of yield, market price, revenues, production costs:
- development of yield and prices per plant,
- development of revenues per square metre.

During the formulation of the vegetable forcing models two types of growing equipment were taken into account: the modern, large foil-covered greenhouses and the conservatory-like greenhouses with a 6-7 metres of valley height.

In the following I defined – on the basis of the primary data collection – the most common farm sizes, thus my models are based on:
- 0,5 hectare,
- 1 hectare,
- 3 hectare,
- 5 hectare,
- 10 hectare farms.

Taking into account the characteristics of Hungary two types of geothermal heating solutions have been chosen, which are as follows:
- heating based on existing thermal water wells (without recharge)
- heating based on new thermal water well (with recharge).

The utilisation of glass-greenhouse constructions was chosen because of forced tomatoes as they are the most common plant in Hungary in newly constructed greenhouses. The most common plant in plastic-covered facilities is the paprika, which is due to the lower investment costs and also the lower operating results.

Results

One of the highest costs of hydroculture vegetable forcing is energy, including heating energy. This is why I considered it important to examine by means of the vegetable forcing models the effectiveness and income generating ability of the heating systems by different constructions as the function of plant size. In practice 100-200 Watts per square meter is calculated for the year-round heating requirement of the forcing equipment. This is why I calculated 200 Watts of annual heating performance in the case of the modern foil-covered greenhouses and 100 Watts for the glass-greenhouses.

As the comparison of the different heating modes and farm sizes is possible only on the basis of equal dimensions I developed an index number. The index presents the development of the operating profit per square meter per 100 watts of heating.

The value of the index is influenced by several factors, since the earning capacity depends on the cost of depreciation, wages, the cost of materials and services per square meter within the production costs, as well as on other factors such as the attainable revenues. In the vegetable forcing models I found that the cost of certain types of heating varies considerably, which is affected not only by the cost of materials used for heating but also by the farm size, since investment costs related to the heating system specifically decrease as the farm sizes increase. The high capital cost of installing new thermal wells can become economical for larger plant sizes.

The development of the operating profit per square meter per 100 watts of heating in the hydroculture forcing of paprika and tomato by different plant sizes is shown in Figures 3 and 4. Within the individual constructions (equipment/heating mode) only small differences were observed in the value of the index at 3, 5 and 10 hectare farm sizes. The advantages of the growing farm sizes were first observable in the case of the three-hectare vegetable forcing models, however, by increasing the size the value of the indicators rises but to a small extent in the case of the 5 and 10 hectare models. When examining the risk-bearing capacity of the vegetable forcing plants the following figures indicate that 3-5 hectare farm sizes are necessary to ensure the expected 25% of net turnover profitability.

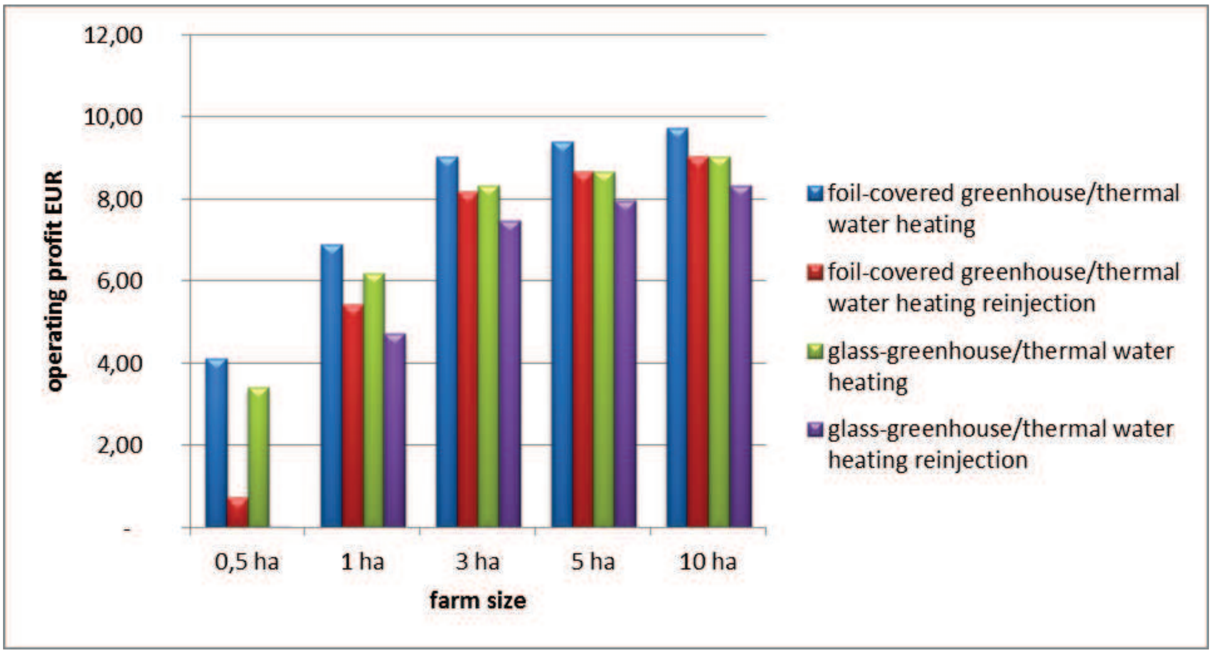

Figure 3: The development of the operating profit per 100 Watt heating capacity per square metre in hydroculture tomato forcing by different farm sizes
Source: own construction

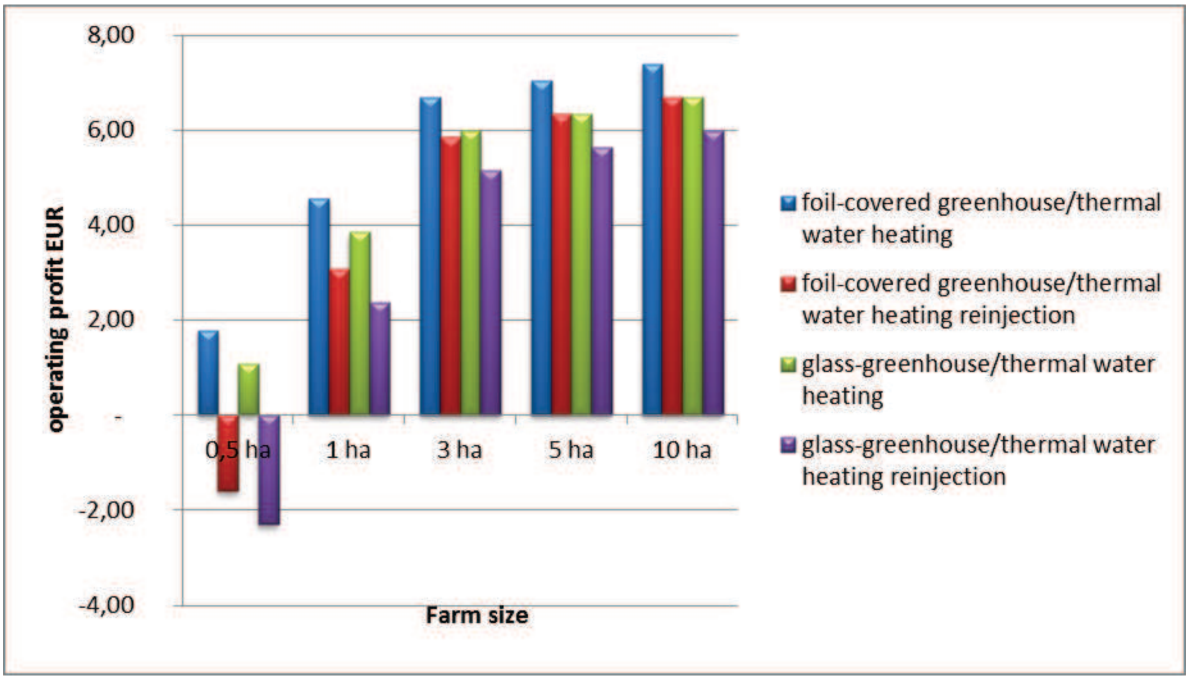

Figure 4: The development of the operating profit per 100 Watt heating capacity per square metre in hydroculture paprika forcing by different farm sizes
Source: own construction

From the point of view of the effectiveness of isolated vegetable forcing one of the most important issues is climate control, which must be solved during the summer by fans. The energy needs of this as well as that of the automated feeding and materials handling systems can be solved in hybrid energy systems. The research of these hybrid energy systems is extremely topical in the sector (Tégla – Szűcs, 2015).
In connection with the business models I determined the investment indicator of the thermal water heating equipment, which is the net present value (NPV). In addition to high-tech greenhouses the investment costs of the geothermal wells had to be calculated as well regarding reinjection operated heaters. This can represent considerable costs, up to € 0.8-1 million per well-pairs. Such a thermal well with adequate water capacity (200-300 thousand m3/year) and water temperatures of 80-90℃ is suitable to provide heat to a 5-6 hectare of economies of scale greenhouse. As for thermal wells without reinjection, on the basis that there are already existing wells, only the investment costs of the greenhouses were calculated, which amounts to €5-6 million in the case of a 5 hectare farm.

The development of NPV both at the reinjection and the non-reinjection model farms is shown in Figure 5. In the case of reinjection the higher investment costs show more favourable values at larger plant size of 5-10 hectares.

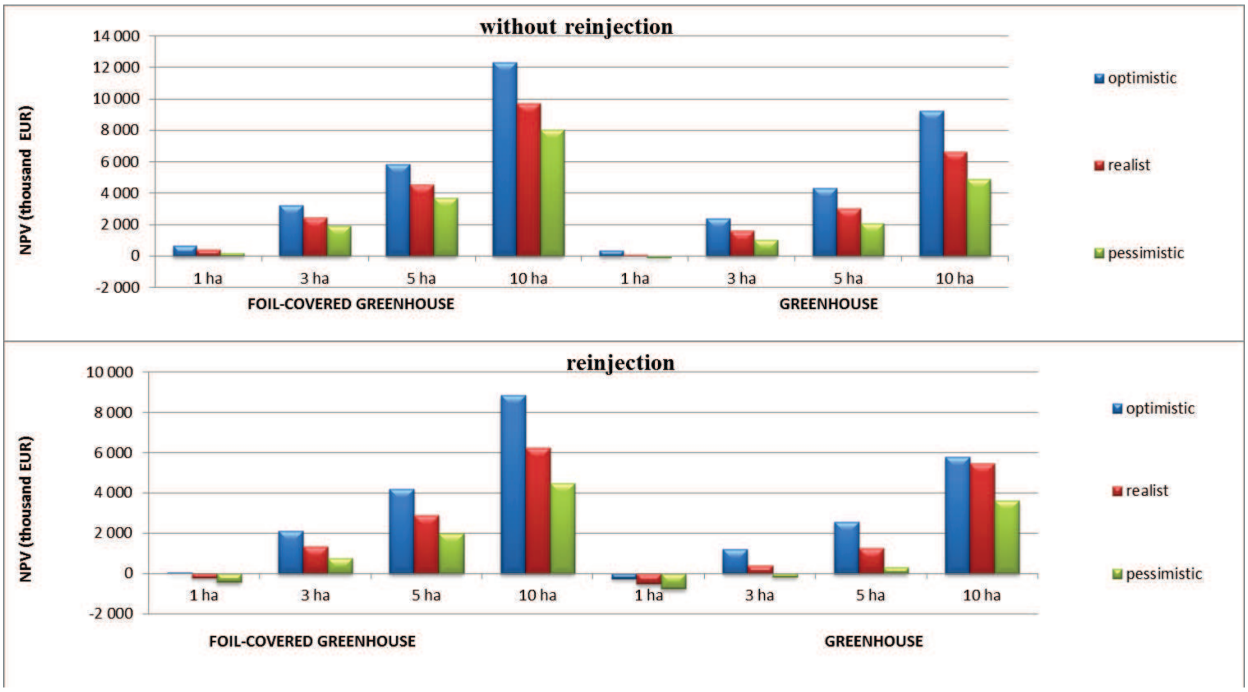

Figure 5: Net Present Value (NPV) results hydroculture tomato forcing by different plant size
Source: own construction

Conclusions

In summary, vegetable forcing in Hungary can be viable only if the final product, which often originates in impoverished rural regions, represents a higher processing level and is able to continuously meet high qualitative and quantitative criteria as well as increased consumer demands. This, however, requires a single, clearly thought-out strategy and program, which can ensure employment and livelihood in the long-term for the rural population by means of utilising renewable resources.

Farm sizes have increased significantly at the international level, which is the result of the high investment costs and the uniform commodity stock expected by the market. Internationally it can be observed that over the past 10 years the 2-3 hectare farms expanded to 5-10 hectares. The competitive advantage of thermal water-based vegetable forcing glass-greenhouses can be retained only if this European trend is followed at further investments. Thermal water heating based horticultural farms are not required to pump the water used for heating purposes back into the ground until 2025 in Hungary. Afterwards, however, reinjection will necessitate very significant investments, which will affect the further growth of plant sizes.

In the case of thermal water heated greenhouses plant sizes are clearly expected to increase after 2025 due to reinjection and higher investment costs. This will mainly hold true for low thermal power (100 W/m^2), high-tech greenhouses that feature a valley height of 7 metres and make high yields possible (e.g. 60 kg/m^2 for tomato).

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Author:

Dr. TÉGLA Zsolt, PhD
Associate professor
Károly Róbert College
Institute of Business Science
zstegla@karolyrobert.hu