INTRODUCTION AND BENEFITS OF SUSTAINABLE AGRICULTURE

MODULE 1

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Intro

The first chapter of the manual is aiming to describe the general benefits of sustainable agriculture. Although the main focus will be put on renewable energies, sustainability is a broader concept. Beyond the introduction into general sustainability issues the specialities of agriculture will be analysed. Some good practices will be introduced to illustrate the role of some relevant renewable energy resources in the implementation of sustainable agriculture. The relevance of the topic is affirmed by its multi-dimensional character. Agriculture as an economic activity has close interrelatedness to nature and society too. Consequently, the realization of sustainable agriculture is a complex task.

Objectives

a. Describe sustainability from different dimensions with a special focus on agriculture

b. Introduce the main types of renewable energy resources as possible triggering factors of sustainability

c. Determine some supporting and hindering factors renewable energy programs must cope with

e. Describe some possible technical solutions available for the agricultural use of different renewables

1.1. Sustainability in general and from a rural point of view

Sustainability and sustainable development are two key words determining the recent scientific, political, and even civil discourse. The definition goes back to the Brundtland Report (1987) The document was titled "Our Common Future", written in the framework of the World Commission on Environment and Development. It explained sustainable development as a way "that meets the needs of the present without compromising the ability of future generations to meet their own needs".

In the interpretation of sustainability, the balance between economic, social, and natural is the main focal point. As agriculture is mainly a rural activity it is worth looking at the sustainability reading of rural areas. The European Charter for Rural Areas (1996) broadened the values and activities attached to rural spaces. There are varied economic functions connected to the countryside, like agriculture, forestry, fisheries, renewable energy production, but rural tourism and recreation should be mentioned too. The functions of agriculture and forestry are under constant re-interpretation. Beyond the production of food and raw materials they must support landscape protection, the maintenance of environmental values and the conservation of cultural and social heritage. As the ecological functions of the rural areas become more and more important, the following values get into the forefront: biological and landscape diversity, environmental protection, native species, non-industrial agriculture, landscape characters.

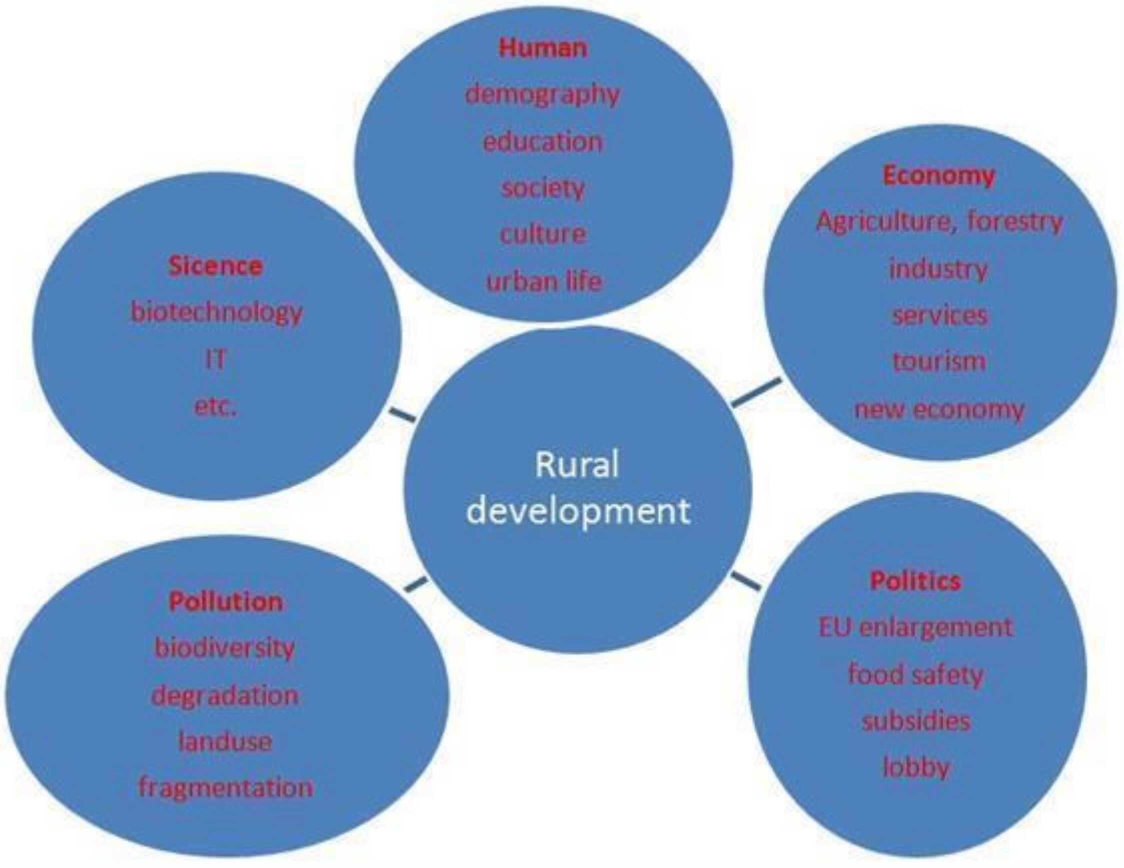

Figure 1 Multidimensional rural development (Source: Patkós Cs. 2013)

Rural areas have important human-ecological and social functions thus supporting bottom-up community-led local development (CLLD) initiatives. Through the mobilization of local resources and channelling local interest into multi-level governance forms these initiatives can realize cases and place sensitive solutions for global problems. The LEADER initiative of the European Union is a great example for this model. Local action groups in the different EU member states in the last 30 years have realized many successful local development projects in agriculture (e.g. local food), tourism (eco-tourism), handicrafts, renewable energies etc.

Rural development must be multidimensional in order to cope with complex problems. (Figure 1)

In the era of globalization there are many challenges rural areas must face. Accordingly, there are many different development alternatives that might suit them. (Figure 2)

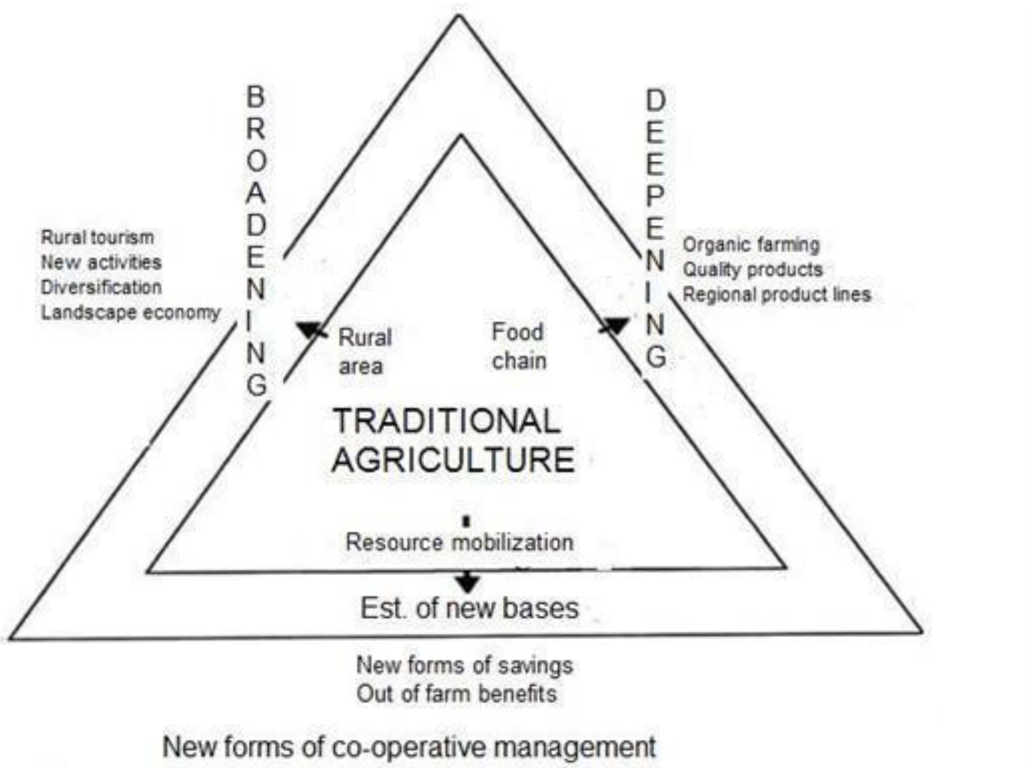

Figure 2 Prospects in the transition of traditional rural socio-economic activities (Source: Patkós Cs. 2013)

The mobilization of new resources is a possible strategy, where new forms of savings and out of farms benefits can help the establishment of sustainable rural futures. More traditional solution is the strategy of broadening, where the diversification of activities focuses on the on-farm activities. The deepening means a more agriculture-centred approach, where organic farming and short food chain development may support the rural renewal.

In the management of rural areas, the protection and use of local, traditional values must have a central role. The primary objective should focus on sustaining and protecting, rather than growth.

Concerning any intervention into the life of rural areas externalities (the unintended effects in any spheres) must be taken into consideration in order to preserve the complex and sensible rural life.

1.2. Sustainability in agriculture

Modern, intensive agriculture can harm the natural environment in multiple ways. For example, a serious effect of agriculture can be the decreasing species density in crop birds. Trying to find possible solutions in agriculture to reserve bird populations is relevant. Sustainability can prevail in any branch of agriculture with putting a main emphasis on long- term cultures affecting the environment to a minimal rate. The balance between production and preservation can be found either in plant production or in animal husbandry. To achieve sustainable goals, farmers can follow different strategies, depending on their local circumstances. Broadly used techniques can be the cultivation of plants that can serve as natural fertilizers, innovative crop rotation systems or drip irrigation.

In this chapter some possible methods will be introduced, based on some Hungarian best practices.

The biologically active and humus rich soil are basic criteria for successful arable land cultivation. The modern tillage practices are usually drastic interventions to the life of the soil. Microorganisms living in the upper soil strata need more oxygen, while creatures of the lower soil prefer lower oxygen levels. Heavy dough ploughs mix the different levels, throw off the sensitive balance and kill huge masses of soil borne organisms, which can't adapt to fast changes. In conclusion the soil becomes infertile. Decreasing the level of soil disturbance is a basic condition of sustainable agriculture.

The Hungarian National Agricultural Chamber has created a guide for farmers about how to reach the proper agricultural and environmental conditions.

1. A minimal soil coverage must be kept after harvesting the Summer and Autumn crop cultures with the use of different secondary crops. Through them the ecological balance can be improved too.
2. Together with the placement of organic fertilizers, a mixing ploughing is needed.
3. In order to minimize the water loss through evaporation it is recommended to compress the soil after tillage.
4. The aim of stubble ploughing is to keep the moisture of the soil, accordingly a shallow ploughing is needed. Its other function is to stimulate the proper heat and biological balance too.
5. It is forbidden to burn stubble, reeds, plant debris, and grasslands, instead it is recommended to keep some of the plant by-products on the cultivated soil and then turn them into the soil.

Organic farming is a key word symbolizing sustainable agriculture. It is a new way of agricultural production to produce healthier products. In traditional agricultural production, plants must be protected from pests and plant diseases, because the consumer market prefers flawless, perfect-looking products. However, these may leave undegraded chemicals, which can cause various diseases and permanent damage to health for many years. Plant protection based on ecology and biology is the basis for healthier organic farming that produces products free of chemical residues. According to the definition of the World Association of Organic Farmers' Organization (IFOAM): "Organic farming includes all agricultural systems that ensure the production of environmentally, socially, economically sustainable and healthy products and food. Protect soil fertility as the key to successful farming. By focusing on the natural balance of plants, animals and soil, it aims to improve the quality of agriculture and the environment. Significantly reduces the input of external resources by refraining from the use of synthetic fertilizers and pesticides. Instead, it allows the processes of nature to prevail in order to increase yields and resilience." There are four principles of ecological farming: protecting the environment, equity, diligence and health.

Organic farming has many advantages as organic fruits are popular with consumers because they contain more nutrients that are important for health, richer in flavonoids and other polyphenols such as resveratrol. These drugs also protect plants from fungal infections and have been shown to be effective against cancer cells in in vitro experiments (Lévite et al. (2000)).

Unfortunately, there are some risks of organic farming too. Because many chemicals that have been developed to provide effective protection for plants against certain plant diseases are not used in organic farming, the plants themselves can become ill and die if they are not adequately protected. Growing the right landscape and resistant varieties is a good solution for organic farming. Resistant plants need virtually no spraying, or only very rarely, especially in the presence of severe infections.

As it could be seen in the recommendations of the National Agricultural Chamber, soil cover can be a key factor in sustainable farming.
Soil cover is a complex method of protection that can be used to make crop production more effective. Its use improves the water balance, reduces the risk of deflation, and protects the soil from erosion due to heavy rainfall. By using the right (natural or artificial) mulching materials, we can significantly reduce soil evaporation, thereby effectively retaining soil moisture. The soil can be covered with different materials. There are cheaper and more expensive solutions for this purpose, such as:

- Black ground cover foil
- White ground cover foil
- Straw
- Hay
- Compost
- Garden green waste, dry plant parts, reeds

A relevant tool of sustainable agriculture is the use of crop rotation. The resting period is often not sufficient to restore soil fertility, and farmers, recognizing this, have found that sowing different crops can fundamentally improve the situation. Crop rotation is an important element of organic farming, as plant protection, weed control and nutrient management are highly regulated and limited in this mode of production. Crop rotation means that the sequence is formed by plants that belong to a different botanically family and have different agrotechnical needs. The soil significantly determines the design of the crop rotation. The more fertile the soil, the more colourful the crop rotation. Crop rotation means that we use the same land in the garden to grow different crops on an annual basis to maximize the expected yield.

Proper ways of fertilizing can support the implementation of organic farming. According to the European Union's organic farming regulations, soil fertility and biological activity may be maintained or increased by the following methods and materials instead of fertilization:

- the cultivation of legumes, green manure or deep-rooted plants in suitable perennial rotations, and
- They can be achieved by introducing organic matter from composted or non-composted organic farming into the soil.

If it is not possible to replenish the soil in this way, the following substances can be used, which can be divided into three major groups:

- organic fertilizers, manure, slurry
- soil improvers, stone dust, slag, ash,
- soil mixtures, compost, animal and food by-products.

Figure 3 Soil coverage with white ground cover foil (Dornink Farm, Washington)

Figure 4 Ground cover with reeds in a vineyard (Szőlészeti Borászati Kutatóintézet, Badacsony)

1.3 Renewable energies as key factors of sustainability

1.3.1. A possible definition of renewable resources

Resources can be declared renewable if its amount does not decrease with utilization and in the future the same amount of energy can be produced from them during the same circumstances. Their reproduction cycle can be counted in hours and days. The traditional (fossil) energy resources can be exhausted as their reproduction cycle can be counted in million years. On the contrary the Sun will shine to the same amount in millions of years independently from our use of solar energy. Similarly, wind is reproduced as well independently from the number of wind turbines harvesting it.

In every EU member state inland wind energy, solar photo-voltaic and solar thermal energies are viewed as renewables. In some of them – because of their special characteristics – some forms are not available, such as ebb and flow, wave and coastal windmills are not available in countries having no seashores. The presence of geothermal energy is again a question of geographic circumstances.

Solar, wind, biomass (from plants and animals) and hydropower energies are directly or indirectly coming from the Sun, geothermal power originates from the radioactive fission processes of the Earth.

The labelling of hydropower stations is not uniform. The energy of water is seen as renewable, but some member states exclude bigger power plants from subsidy programs of renewable energy projects. (e.g. United Kingdom 10 MW, Germany above 5 MW). Although the negative environmental effects of hydropower are well known, the directives of the EU see it as renewable irrespectively of its power capacity.

In many member states (United Kingdom, Belgium, Netherlands) energy from the incineration of waste is declared as a renewable resource. According to the EU point of view only half of the electricity can be declared renewable produced from the organic part of industrial and urban waste.

It can be summarized that in the EU member states the following ones can be declared renewable energies:

- direct solar energy,
- wind energy,
- geothermal energy,
- wave energy,
- ebb and flow energy,
- biomass
- hydropower,
- additionally biogas from biomass and sewage.

In the following pages more detailed information will be provided on solar, wind, combined (solar and wind together), geothermal, biogas and biomass harvest opportunities.

1.3.2. Opportunities to use renewable energy resources

The availability of renewable energy sources is dependent on the geographic location, natural characteristics (e.g. surface), economic circumstances, and political factors are of great relevance. Additionally, technical and technological considerations and the social background must be taken into consideration. (Imre, 2004).

Natural characteristics:

- the intensity of solar radiation (energy), the number of hours of sunshine
- the characters of land (the ratio of plane and mountainous areas, soil conditions, forest areas etc.)

- wind characteristics (speed, direction and their frequency)
- hydropower stock
- geothermal energy availability
- biomass fuel availability

Economic environment:

- the price level of fossil (oil, natural gas, coal) fuels
- the price of nuclear fuels
- the level and margins of the costs of energy production
- the state subsidy on the price of energy resources

Political circumstances, general opinion:

- objectives, aims, concepts
- strategies, organization and direction
- environmental aspects
- the types and level of state-support
- international programmes and the national commitment in them (EU directives, Kyoto Agreement)
- price-influencing factors (purchase price, tenders, quota obligations, tax reductions etc.)
- broad rejection of nuclear energy

Technical and technological factors

- development programmes related to renewable technologies
- characters of the electric grid, capacity

The social environment

- environmental consciousness of the society
- comparison with traditional technologies, questions of effectivity
- local resistance against some applications (windmills, hydropower stations)

The above factors are quite diverse in the different EU member states, consequently the conditions of utilization can be diverse. (Imre, 2004).

The natural conditions originated in the geographical location of different countries influence the potential of the different renewable energy resources.

The size of hydropower energy potential is affected by the runoff, climate and other factors influencing the water cycle parameters (the amount and distribution of the annual precipitation). Accordingly, in the EU the following countries can be declared as advantaged ones: Austria, Sweden, Portugal, Finland, Spain, Italy and France.

Concerning solar energy utilization, the conditions of Southern European (e.g. Greece, Spain and Italy) are really favourable. In the Mediterranean countries having dry Summer and a small ratio of cloud cover much more solar energy can be harvested either directly or indirectly.

The velocity of wind can be broken by higher landmarks and the relief conditions. As the wind blowing from the sea eases to a smaller extent, countries having the most favourable wind energy potential are situated near the North, and Baltic Seas and the Atlantic Ocean. The United Kingdom, Ireland, France, Denmark and Spain have good wind capacities. The annual amount of the energy produced by a wind turbine in Ireland is twice as much as the production of similar equipment working in Germany.

Concerning biomass in the EU, Finland, Denmark, Luxemburg, the Netherlands, Portugal, Austria and Sweden are in a favourable condition. Additionally, Hungary has quite good soil, temperature and radiation conditions, only the temporary lack of water can hamper the intensive biomass production.

The geothermal energy resources in Italy, Portugal and in Hungary are quite favourable.

1.3.3. The utilization of renewable energy resources

The use of renewable energy sources can be justified by three main factors:

- the amount of traditional energy sources is decreasing, the recently known stocks will be exhausted in 30-50 years
- the costs of accessibility will be bigger
- they can play a relevant role in the mitigation of greenhouse gases

Based on the Kyoto Agreement, in connection with the emission of greenhouse gases the EU was committing to ensuring that a 8% decrease would be realized related to the 1990 level. The eight member states assuming mitigation are as follows: Austria (-13%), Belgium (-7,5%), Denmark (-21%), United Kingdom (-12,5%), Germany (-21%), Italy (-6,5%), Luxemburg (28%).

To spread renewable energy resources to a great extent, social consciousness must play a crucial role. Enlightening, effective teaching and educating activities, presentations, conferences and common enterprises can support the development of a positive social attitude. In some countries it is possible for consumers to buy green electricity even at a higher price. In the Netherlands 13% of the households have decided to use more expensive, but green energy. It is important for the consumers to be informed about the source of energy they are consuming. Knowing this information, the consumer may change the supplier.

1.3.4. Barriers against the fast development of renewables

While, there is supportive political volition and a high level of environmental awareness in many countries, there can be many factors to block the diffusion of renewable energy harvest.

One main barrier is the relatively high price of the technology. An extremely high investment cost can be calculated in case of bigger wind power stations. Possible state subsidies may broaden the scope of such investments.

Another huge challenge is that while the use of traditional fossil energy resources is not burdened by externalities, but on the contrary, they gain support (in the middle of the 1990s the amount of this subsidy was 250-300 billion USD worldwide), the renewables do not get so much support.

The problem of externalities in case of fossil resources can be counteracted (e.g. through coal taxing). After the 2002 Barcelona Summit this objective was declared as a direct goal and the 2001/77/EC directive aimed to abolish the hidden support of fossil and nuclear fuels. At the same time the European Council confessed the importance of nuclear energy as well (Green Paper, EC 2000 b).

Solving the problem of storage can help the further spread of renewable energy resources as this is one of the main barriers of their further penetration. The traditional batteries are unable to store energy effectively as their specific energy density is low (30-35Wh/kg). With the development of innovative, new energy storage technologies their spread may be supported to a great extent.

In the formation of the future of renewable resources prices and political support can have a relevant role. The growth of subsidies towards them and the internalization of externalities in case of their fossil counterparts can be decisive.

The ratification and implementation of international climate agreements will have a further positive impact on them.

1.3.5. The use of renewable energy resources in agriculture

Agriculture in general has notable energy demand, but at the same time the sector can produce a great amount of renewable energy through its main or by-products (e.g. biomass, biogas or bioethanol). The scene of agricultural production – the soil itself – can be a renewable resource too. Nowadays the vast majority of agricultural production takes place on this medium, although aquaponic and vertically deployed vegetable cultures are spreading nowadays too. In grain crop and feed crop production these new methods are not effective enough.

The energy demand of agriculture is mainly coming from tilling activities, but of course huge amounts of energy is needed for harvesting, transporting of plants too. The development of mechanization made possible the birth of industrialized monocultural agriculture using big plots of lands. Yields were growing thanks to the use of chemical fertilizers. The growth in the number of roots in a piece of land and the use of more intensive producing technologies has evoked the growth of demand for irrigation water and the risk of the incidence of plant diseases. Consequently, the frequency of the use of insecticides has grown meaning a much bigger cost for agriculture. It can be concluded that the agricultural production was not economic and sustainable for a longer term in Europe. Because of the continuously growing production costs, profitability in many locations started to decrease to a great extent. Because of these trends many farmers started to think about changing the former extensive and quantity-based agricultural production with a more qualitative, ecological chemical-free way of production.

If the use of machinery and chemicals in agriculture is decreased, the agricultural production will be sustainable.

Sustainability in the case of agricultural production results in decreasing the dependence from the ever-changing prices of fossil fuels, chemicals and artificial fertilizers on the world market to a great extent. If an independent irrigation, hail damage and frost protection system is also available, the dependence from weather extremities might be decreased too in the future. The use of greenhouses and plastic tunnels may decrease extreme weather exposure, additionally vegetables and fruits can be produced off-the-season. The length of the vegetation period can be increased to a great extent as well. At the same time, the heating demand occurring in the Winter period may increase the energy dependence of agriculture, particularly if the heating is based on non-renewable energy resources. If the heat demand is provided by solar collectors or geothermal systems, then the agricultural production can be declared sustainable.

If the total energy demand in agricultural production can be covered by renewable energy resources corresponding with local circumstances and possibilities, then our production activities can be stated as sustainable.

Sustainability and the use of renewables can not be separated in an up-to-date agricultural production, together they can be successful. The main profile of the agricultural enterprise and the environmental, geographic, geologic circumstances of the cultivated land may determine the suitable form of renewable energy to cover the energy demand.

For dairy farmers it is inevitable to use hot water, but as it is a periodic demand, the use of solar collectors can be suitable. For the production of first fruits and vegetables the continuous supply of hot water is a must to heat plastic tunnels and greenhouses. Geothermal energy can be the best solution for this problem, namely, to drill thermal water wells near the facilities. The relative closeness is important, as draining the thermal water to greater distances can decrease its temperature and so the effectivity worsens.

The operation of cold stores, oasts needs a tremendous electricity demand for enterprises in agriculture. The way of electricity production should be selected adequately to the local climatic conditions, accordingly we may choose solar cells or wind turbines. In case of both forms of energy the question of continuous availability is crucial. Unfortunately, in the majority of the European countries the availability of solar and wind energy is not persistent. Consequently, renewable energy systems are worth operating in a network working method. It means that the electricity provider company takes the produced surplus energy and supplies the demand if the own production can't cover the needs. Of course, renewable energy production can function in an island mode of operation too. In this case to build a so-called puffer-storage capacity is a must. It can be implemented in the form of storage batteries. This way is an independent and autonomous energy supply system. Its disadvantage is that the creation of the storage batteries can make the system much more expensive and its space requirements are bigger (a separate, watertight, dry room is needed) than that of the networked systems. At the same time enterprises, choosing the island type don't have to be afraid of the rising prices of energy supply. In both cases the electricity needs of the given enterprise must be detected and the required capacity should be settled.

Of course, the seasonal availability of the different forms of energy must be taken into consideration. In case of the networked systems an annual balance between production and consumption is enough, as incomes from possible Summer energy overproduction may cover the costs of energy bought from the network to meet the needs of the Winter consumption. Accordingly, in case of island systems in order to secure the continuous availability, it is reasonable to built-in bigger capacities than the average consumption to survive periods of energy gaps.

1.3.6. The energy needs of agricultural production

Manure, coming from animal husbandry, can help the preservation of the productiveness of soil and may be used in biogas plants too. Greater amount of energy is needed for the husbandry of smaller and younger animals as they have to be kept warm in case of any external thermal circumstances, additionally the fresh and clear air should be provided as well. For keeping bigger animals for slaughter the heating is not a must even on Winters if a dry and roofed place can be provided for them.

In a well-functioning agricultural enterprise animal husbandry and plant production are attended together simultaneously. By-products of animal husbandry (e.g. manure) are of primary importance as fertilizers, but they may be used as raw materials in biogas power plants as well. By-products are created during plant production too (e.g. straw, prunings) that may be the base of biomass-based heating or can function as raw materials for biogas too.

The basic objective in case of the utilization of any renewable energy resource is to transport the agricultural raw materials and by-products to the closest existing suitable energy power plant. Accordingly, it seems sound to set up biomass-, biogas- or bioethanol-based power stations, in the area of agricultural enterprises. These can help to use all of the by-products created by the agricultural activities. The creation of power plants is much more expensive, and their payback period can be counted even in decades.

Of course, the majority of agricultural waste can be composted which is one of the most environmentally friendly ways of improving the productivity of soil. Traditionally the main objective of agriculture is food production. This activity needs good soil conditions, which must be secured by regular fertilization. In this way all of the traditional by-products can be useful for the plants. In some cases the waste is used for the production of bio-briquettes or biogas, in these cases fertilizing can be solved by animal husbandry by-products (e.g. manure). Beyond fodders, animal keeping requires other plant-based by-products too, in order to secure the basic hygienic and comfort circumstances to keep animals indoors. Animal bedding is a must to keep stock clear and provide them rest. Without proper bedding animals can get ill more frequently and a tremendous mortality rate can be counted.

If a farm wants to be fully energy-independent, then it is a must to produce energy for the machinery too through biogas or bioethanol generation. At the same time, it is ambiguous to make it economical to build up such plants at the era of a global change when internal combustion engines are on the way to be replaced by electric ones. Today it is not clear when electric engines will be introduced in the market of agricultural machines, but as environmental regulations become stricter the transition seems to be inevitable. This means that instead of the building of pure biogas or bioethanol plants, electric power plants should be settled down in case of agricultural enterprises too. Presumably, the role of solar cells and wind turbines will have a bigger role in the life of farms in the future.

In some agricultural activities the need to produce sanitary hot water is huge. In the case of animal husbandry, mainly in dairy producing farms, a great amount of hot water is used. Accordingly, it seems expedient for dairy to set up solar collector system capacities enough to provide the daily needed hot water for the stock. In the Winter the longer, cloudy periods can cause problems, therefore in view of the local climatic conditions much bigger heat storage capacities must be created in the given farm.

Solar collectors can be settled not only on the roof of buildings, but these can be put on the soils providing the most appropriate angle. Solar collectors can produce hot water with a high effectivity rate, but for electricity making solar cells must be used.

Recently solar or photovoltaic cells are widely used utilities of electricity making. Nevertheless, their effectiveness rate is smaller than that of the collectors, their use is popular in case of domestic use or in smaller power plants. Usually the roof of houses is used to settle them, but in bigger utilities the soil surface is the appropriate place. During its use the continuous clearing is a must as in dusty atmosphere conditions it becomes dirty fast and the effectiveness of energy production worsens to a great extent. During the installation of these utilities it is a must to secure the proper orientation towards the cardinal directions and the right angle too. The most effective angle – where the most energy can be produced – is around 45 degrees and in the Southern cardinal direction. At the same time in case of this orientation during sunrise and sunset the energy production effectivity level worsens to a great extent as at low solar angle of incidences only a limited amount of light can reach the cells.

In the case of agricultural activities electricity, produced by photovoltaic cells can be used for the operation of cold storages, fans and other electric utilities.

In some farms, greenhouse or plastic tunnel operation may demand a significant amount of heat energy. In order to cover it geothermal energy seems to be a proper way. Wells of hot water can provide heat for greenhouses and plastic tunnels effectively even in Winter months. To drill geothermal wells, it is a must to respect legal regulations of the given country. In many cases it means that it is obligatory to return the exploited hot water (after proper cooling) to the original rock strata through a parallel pipe system. Technically it needs at least two drills and it increases the costs. Additionally, one must pay attention to the chemical composition of the water, namely what type of salts can be aggregated and accumulated during operation to avoid the clogging and blockage of the pipes. Besides, one must care about the proper diversion and treatment of arising gases to avoid explosion or possible air pollution.

The type and character of the farm determines the amount and form of the energy demand. Accordingly, after the estimations of the demand it is expedient to decide the form of energy production. Of course, these utilities can be combined. In many locations hybrid power stations can be found, consisting of wind turbines, photovoltaic cells and solar collectors. Through them energy production will be more stable as it can be stated that at nights when there is no light the wind occurrence is more frequent. Additionally, there can be seasonal differences in the availability of wind and solar energy too. The solar potential is clearly at peak in the Summer and at minimum in the Winter. In the majority of Europe, the wind speed is the highest in the Winter and Spring. We may conclude that solar and wind energies in time complement each other.

A widespread technical solution is to produce hydrogen by wind turbines. This gas can be stored in huge tanks and can be used by engines in case of necessity. The same energy-producing circle can be used in biogas power plants too.

Soil and its fertility are renewable natural resources in agriculture. In default of proper soil fertility neither food nor fodder production can be realized. Namely, it can be said that only in the case of proper soil conditions can any agrarian activity be followed. Soil fertility shows a clear annual cycle as on the one hand huge amounts of precipitation can wash away nutrients from the soil and on the other hand low temperature slows down micro-biological processes. A proper soil ecosystem can be created by chemical-less agricultural production. Micro-organisms living in the soil (azotobacter, rhizobium, clostridium) produce a significant amount of nutrients for the plants, additionally they support humus creation and improve the water containing ability of soils too.

If chemical fertilizers, soil disinfectioners or other chemical materials are frequently used in production, these useful microorganisms may be destroyed, and the soils can lose their fertility. Without the use of proper methods of fertilization, the cultivation circumstances worsen to a great extent. Animal manures are traditionally used to improve fertility. They are beneficial for the conservation and continuous maintenance of soil organisms. As manure is available in sufficient amounts from animal husbandry, the problem of transportation, placement and even spreading must be ensured. Thereby, huge amounts of by-products of animal keeping will be used. During plant cultivation many stem residues, non-used plant parts, prunings are arisen. Their treatment is a usual challenge for farmers. These by-products are sometimes burned without proper management, causing significant air pollution.

A really effective way of fertilisation is to compost plant parts. With the collection of non-used plant parts (even grass growing around the land plots) large amounts of organic materials can be placed into composting units. Through these facilities large amounts of bio-humus can be produced and transported to arable lands and gardens.

Bio-humus or soil mixed with bio-humus and peat can be used separately or can be sold if the farm does not need them. With composting the fertility of soils can be preserved in an environmentally friendly way, without adding extra chemicals. Biological and eco-production has become more and more important all around in Europe and the role of plant parts and bio-humus will be more relevant in the future.

1.3.7. Possibilities of the use of different renewable energy resources in the agriculture

1.3.7.1 Solar energy

The absorbing surface (solar cell, collector, solar cooker) can utilize solar energy with the greatest efficiency if the radiation reaches that perpendicularly. In an ideal case the surface should be installed on a two-axis rotatable system following the daily sun-path automatically. Unfortunately, this condition can be secured only with the installation of expensive equipment. A satisfactory result can be reached with the adequate orientation of the absorbing surface taking into consideration the North-South direction and the difference between the Winter and Summer angles of incidences. The Southern orientation is inevitable, and the angle of inclination is determined by the efficiency of the utility and the geographic latitude. The bigger the efficiency is, the smaller inclination angle can be chosen to exploit the Spring and Autumn sunshine too. In agriculture a suitable place of use of solar energy is the roof of livestock farms and crop containers.

Solar energy harvest can be divided into active and passive types. The architectural (passive) utilization is based on the proper planning of orientation and positioning of the buildings in order to absorb, store and use the maximum possible amount of solar energy in a natural way. With adequate planning and implementation solar energy as an auxiliary heating might result in a 30% fuel saving in the Winter months. In the Summer through solar collectors, hot water can be produced with favourable conditions, additionally this energy can be used for air conditioning. Accordingly, the temperature of our home can be comfortable all year long with moderate expenses.

Basically, each and every building, plastic tunnel and greenhouse can be declared a passive solar energy user, where the light of the Sun is let in. As the lifestyle of our ancestors was more natural, traditional experiences prevailed in their buildings. For example, the orientation of traditional farmers' houses was optimal, the porch could provide a harmonic solar energy use in the Winter and shading in the Summer. Unfortunately, urbanized building structures limited the use of solar energy only to the possibility of natural lighting and a complex exploitation became almost impossible. The only exceptions can be the modern skyscrapers, where large glass surfaces make the use of solar light. The modern detached houses are not optimal from an energetic point of view as compared to their useful cubic capacity their energy consumption is large, if their thermal protection is not secured lately (insulation).

The primary task of passive solar energy use is to provide solar energy for the heating of buildings in periods of natural energy shortages. There is no need to provide heating for greenhouses and plastic tunnels in the early Spring or late Autumn. Against smaller frosts even a one-layer plastic folio or glass can provide protection mainly for cold resistant plants. The favourable orientation and the intensive greenhouse effect in these special closed spaces make possible the earlier or later growth of plants.

Hay and straw used for animal husbandry can be stored safely if they are dried in the sunshine. Without this step their storage and utilization for animal breeding and littering in the Winter months is not possible. The passive energy utilization can be the most effective during the transitional seasons, when there is a heat loss on the building, because of lower external temperature, but the sunshine is still strong. In this way the passive use can support or even replace the active heating systems. The effectiveness of passive solar energy use can be 15-30%.

1.3.7.2. Wind energy

The majority of wind turbines produce electricity but there are other systems, moved by the wind that run pumps and exploit water from deeper strata of soil for fishponds and irrigation. In the case of fishponds in the summer the lack of oxygen is a great challenge. In order to solve this problem wind turbines propelling aeration wheels were developed. (Figure)

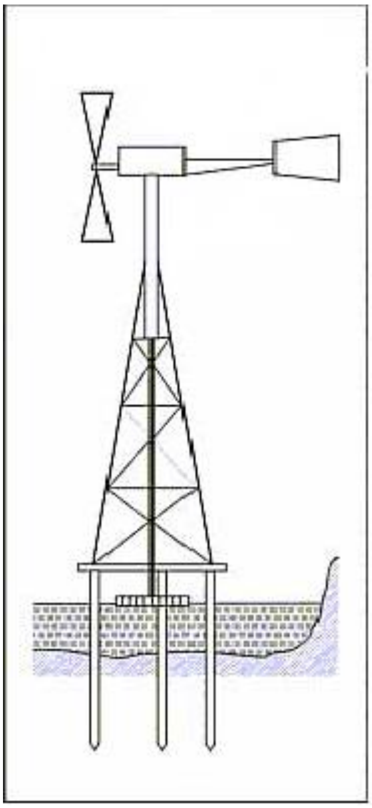

Figure 5 Wind turbine propelling aeration wheels (Source: Lakatos L.)

According to environmental investigations the decay of natural waters is a more frequently prevailing problem. To provide oxygen for artificial special fish farms and other bodies of water to produce fingerlings is also a problem. These challenges can be solved by aerators. Aerators supported by wind energy in many cases are more economical, easy to install – they can be put on buoys – and mobile. The unbalanced or temporarily intermittent supply does not block out the utilization. The vertical axe can be used here for the direct drive of the aeration.

In Balmazújváros (Hungary) there were experiments with the bio-wind-engine to aerate wastewater ponds. During the experiment a whole wastewater system could be cleaned up in six months with wind turbines mixing and stirring the water.

1.3.7.3. Hybrid systems: solar and wind

The simultaneous use of different renewable energy sources can significantly improve the rate of usability. Solar and wind renewable energy are often used together for energy production. The benefit of this is that in summer the solar energy, while in spring or in winter the wind energy is primarily available abundantly. It's important to investigate how to change the lengths of the inappropriate period for energy production in each month of the monitored year for the two renewable energy types, that is, how long can we expect our solar or wind equipment not to generate electricity for us. On the basis of a dataset of hourly solar radiation in the period of one decade we can experience on potentially wind energy data that from April to October the solar energy can be used more safely than wind energy. On the other side it seems to be that from November to the end of March the wind energy is the more safe energy form. If we use the two energy forms, namely by means of hybrid energy production can regenerate the renewable energy; substantially more stable, we can get to the renewable energy with almost continually available (Figure 6).

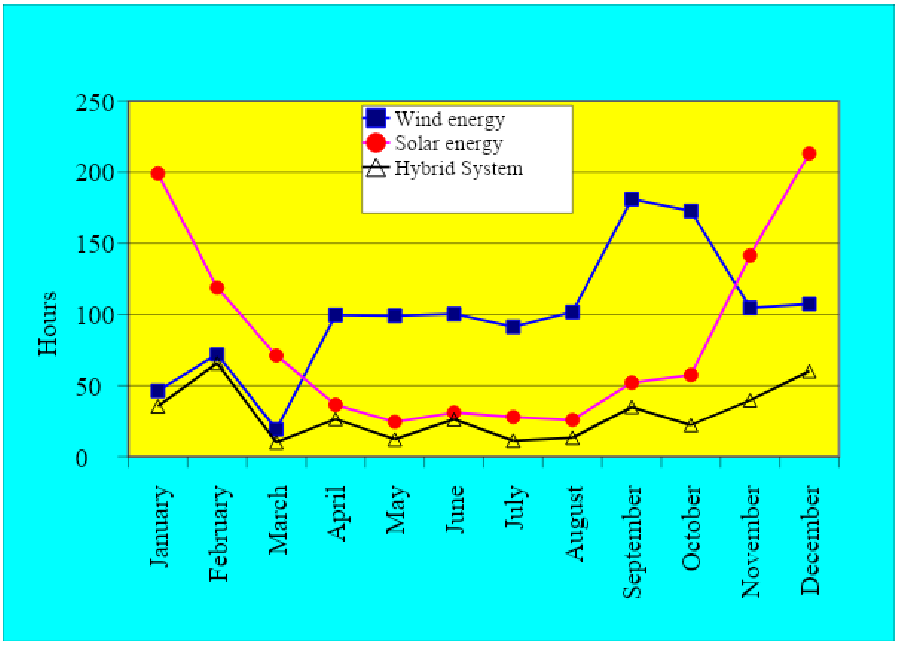

Figure 6 The annual changes in the maximum period of free energy production term with use of solar, wind and hybrid systems /1996-2005/ (Source: Lakatos L.)

1.3.7.4. The use of geothermal energy in agriculture

The geothermal gradient has a very favourable value in Hungary, so water with a temperature of about 50ºC can be obtained from a depth of approximately 1000 meters and more than 70ºC from a depth of more than 1500 meters. There are about 620 thermal wells in our country whose water temperatures are higher than 35ºC. In the case of 180 piece wells, the water temperature was higher than 60ºC, so they can be used well for energy purposes.

The thermal water can be used directly for heating of polytunnels and greenhouses. In addition the hot water is used for heating houses, livestock buildings, hatcheries and a lesser part for drying of the agricultural crops. Usually, the energy provided by thermal wells is used during the winter months, so they are not used for a significant part of the year. The direct use of thermal water takes place in an open system and with multi-phase utilization the goal is to keep the leaving water with the lowest temperature as possible. Depending on the temperature of the thermal water, the greenhouses can be heated in one or two steps. Water cooled to 30 ºC can be used for ground heating and preheating of irrigation water. Due to the significant salt and limescale build-up, the pipe system usually needs to be cleaned monthly, as the build-up significantly reduces heat transfer and also narrows the flow cross-section.

In the case of greenhouses (similar to polytunnels) air heating is used, which is supplemented by ground heating, especially if the temperature of the thermal water is low. In the case of permanent heating operation, smooth or ribbed pipes or convectors are used at the height of the gutter on the side walls. If it's possible, it is advisable to place the heating pipes low (although this sometimes worsens the use of space), because this way approx. 15% less energy is required.

When designing underfloor heating, a pipe system made from plastic (KPE, or other long-life plastic) is laid 25-50 cm below the soil surface according to some geometric shape, so that the greenhouse's area is evenly and densely networked. Combined, radiant, convection and air heating are used to the greenhouse. More recently, heating mats and vegetation heating have been used instead of underfloor heating.

The heating mats are made from 10-16 mm hoses which are connected by chain looping. Between the rows of plants and along roads, they also reduce water evaporation and weed growth. If appropriate, they can be placed on walls and in the soil.

The ribbed plastic pipes with a diameter of 20-40 mm in vegetation heating are laid to the ground. In the case of both vegetation heating and the use of heating mats, low-temperature thermal water heating can only be mentioned and their common feature is that the temperature is optimal around the plants. Their great advantage against underfloor heating is that their install and repair are substantially simpler and cheaper.

Thermal water cooled to about 20 ºC can be further utilized in the case of double-walled film tents for the water curtain heating. The low-temperature thermal water leaving the soil or vegetation heating system flows between the two film layers and forms a thermal insulation layer. Disadvantage is that it can only be achieved with a large amount of water.

Necessarily, geothermal energy can not only be used in crop production, but can also be used to the heating of farm buildings and to the hot water's service. Available hot water outside the heating season e.g. can also be used for crop drying. Direct thermal water can be used in all cases where only lower temperatures are allowed or sufficient when drying the crops. The most important cases are the followings:

- seeds drying,
- fruits drying and dehydrating,
- starch, yeast etc. drying,
- preheated air ventilation and drying.

The geothermal energy can be used only with a combined method for the hot air grain crop dryers which work at a higher temperature.

In animal husbandry, the existing geothermal energy is mostly used in poultry farming. If we have high-temperature (80-90 ºC) thermal water, we can also consider installing ceiling-mounted radiant screens, although we can use this hot water in another way. It seems more appropriate if it's used underfloor heating with lower temperature thermal water which is leaving the system.

In addition to floor heating, the so-called wall panel heating is a widespread heating method as well. In these cases, the goal is not primarily to heat the air, but to create the acceptable hot feeling through radiation.

Thermal ventilators heated by thermal water are well suited for air space heating, which also have thermal and air control.

1.3.7.5. Biomass as energy resource

Biomass is an indirect use of solar energy. Agricultural and forestry production is actually a transformation of solar energy.

Biomass is regenerated, and the accident risk of its production, collection and use is lower as the coal and oil exploitation. It can also be transported over longer distances. The biomass incineration has got a lower environmental pollution's effect than fossil energy production (its sulfur emissions is only twentieth of the inland coal). Slag formation is low, eco-friendly, and its ash can be used as a soil nutrient. It can be transported and sold well in compressed and compact form (e.g. pellets, fabricated briquettes).

The source of biomass

1. Herbaceous energy crops

These are perennial plants that are harvested annually after reaching their full development in 2-3 years. These species are e.g. bamboo, elephant grass, energy cane (Myscanthus sp.), or Szarvasi-1 energy grass which is a sublimation product from Hungary (Figure 7). The Szarvasi-1 energy grass is a perennial, bushy top-grass. From its stem a strong, massive root system probes deeply (1.8-2.5 m) into the soil. The caesious stems are sparsely leafy, straight, with a smooth surface, hard and 180-220 cm in height. Its caesious leaves are stiff and slightly rough. It shoots in mid-April, blooms in late June - early July. The grain is ripe in late July - early August for harvest.

Figure 7 The Szarvasi-1 energy grass

2. Woody energy crops

These are fast-growing hardwoods that can be harvested a few years after planting. After their first cut, they start to bush and can stay in one place for 10-15 years; they can be cut every 2-3 years. These species are for example: poplar, willow, black locust, silver maple etc. (Figure 8)

Figure 8 Summer forest (5 years old) in Tata

3. Food crops

These include plants produced for food purposes, such as cereals, sugar beets, potatoes, soybeans, etc. It is also true for these plants that their whole or unused parts, such as agricultural waste, can be used for energy purposes.

4. Technical crops

These have been refined to the industrial needs, e.g. paper industry, textile industry, lubricant production, etc. In general, these plants, in whole or in those parts, which are not used for industrial purposes, are suitable for energy utilization.

5. Rural vegetable waste

These include mainly the various stems and leaves and other parts of the plant, most of which currently remain in the fields. For examples are corn stalks, leaves and cobs, cereal straw or rice stalks. Many by-products - straw, stalks, trimmings, shear, maize cobs, leaves, etc. - are used in agriculture to obtain thermal energy by direct incineration and available with an energy value equal to the value of the main product - seeds, tubers, fruits. The energy generated during the incineration of dry crop waste and by-products can cover the heat demand of spaces and processes, and in power-heat transfer equipment it can produce electricity and heat. One of the largest annual by-products of crop production is straw, which represents approx. 15 GJ thermal energy per ton.

6. Forestry waste

This wood waste is generated during forestry function, which after the extraction and removal of the main product, mostly remains in the forests or at the place of primary processing, and they can also include dead or unhealthy trees.

7. Animal waste

Agriculture and animal husbandry generate such animal waste that can have a detrimental effect on the environment, but is also a complex source of organic matter. These materials can be used for energy production, among many other purposes. These can be, on the one hand, various animal manures, but we can also include slaughterhouse waste and the carcasses of dead animals and their parts.

1.3.7.6. Biogas as energy resource

Biogas can be obtained from any organic waste that contains biodegradable material. Biogas is produced as a metabolite of methane-producing bacteria. During the anaerobic process, the solar energy stored in the organic matter is converted into a gaseous energy carrier.

The utilization of animal by-products means primarily the production of biogas. Already today, there are operated biogas works around the world, the production of which is mainly used to support their own energy needs. Here, the economics question is brought up, in deciding which the environmental effects of the slurry decomposition must also be taken into account. One of the limiting factors of the spread and operation of the pig farms is the good solution of manure management and the harmonization and operation of the farms with the environmental protection requirements.

A special possibility is the utilization of gas produced from biomass for energy purposes and for energy self-sufficiency. At first sight, biogas appears to be a favourable option because it is produced from a material that we do not consider reusing for other purposes (except for soil replenishment). The energy utilization of biogas or landfill gas (gas generated from municipal waste in landfills) is technically favourable. However, these opportunities can only be exploited costly. The high cost of biogas production is due to the fact that two significant storage volumes have to be established for the process: the fermenter and the gas storage. Both volumes are expensive because both organic matter and biogas have a low energy density, so 100 m^3 size must be taken into account to meet the energy needs of the household. (It must be clear to see that 1 liter of fuel oil corresponds to 2 m^3 of biogas in energy terms.) The volume of the biogas storage can be reduced by gas compressing, but this requires a significant energy and significantly reduces the efficiency of the system.

The so-called raw biogas from fermentation is a gas mixture whose most important components are the followings:

- combustible methane (CH4), 55-70%
- not combustible carbon-dioxide (CO2), 30-40%
- Hydrogen (H)
- Hydrogen-sulfide (H2S)
- Carbon-monoxide (CO)
- Oxygen (O2)
- Nitrogen (N2)

The anaerobic fermentation

Anaerobic fermentation is a natural bacterial degradation process that also takes place in the rumen and bogs of ruminants. Degradation is a complex, multi-step microbiological process in which biological materials are broken down into smaller constituents by different groups of bacteria. Methane and carbon dioxide are released from biological materials during anaerobic fermentation. The process can be accelerated by keeping the raw material “cocktail” in a closed container at a controlled temperature, pressure, or pH to optimize the conditions for bacterial processes. The evolving high methane gas can then be easily collected for use.

Conditions for biogas production:

- organic material
- anaerobic environment

- presence of methanogenic bacteria
- constant, balanced temperature
- continuous mixing
- properly shredded organic matter

The amount of raw biogas components can vary widely and depends on:
- from the raw materials used in the fermentation
- their proportion
- resulting fermentation space loading
- from the fermentation temperature
- duration of fermentation

The amount of methane is usually 66%, but practice shows that the additional intake of certain organic wastes (e.g. green plants) can increase this value to 85%. The calorific value of biogas varies between 10-25 MJ / m3 as a function of the methane content, which increases continuously depending on time (for a certain period of time).

Comparing biogas with other energy sources, we can state that 1 m3 of biogas is equivalent to 22 MJ / m3 calorific value.

1,37 m3 with city gas

0,48 m3 propane gas

0,66 m3 natural gas

0,61 l oil-fuel

0,72 l petrol

6,1 kWh electrical energy

In practice, the raw materials for biogas can be:
- sewage sludge
- animal manure
- municipal waste
- slaughterhouse waste (3. class. maw-, and intestine-contents, blood)
- crop production waste
- canning, food and restaurant waste

Livestock farms pollute the air and water in Hungary. If you start along a stream, you will sooner or later find stalls that stink of slurry. There was a case in Bükk, manure juice dripped into a funnel collecting the drinking water of a village barely 100 steps from the source of the stream with plenty of water coming out of the mountains. EU membership is now forcing Hungary to suspend this type of environmental damage. Within agriculture, livestock farms are the ones now more closely monitored by the Environmental Inspectorate, given the fulfillment of various commitments associated with EU accession and the fact that for decades, livestock farms have left something to be desired. According to the government edict in force today, the introduction of manure, slurry and related leachate into the waters is prohibited.

The used method in the biogas works completely eliminates the harmful effects. The decomposition of undesirable substances in the air takes place here, which releases methane, which is a very good fuel - one of the components of natural gas - and this is biogas. In Hungary, the manure production of livestock farms provides an excellent basis for the production of biogas. Technical equipment and technologies are available. Unfortunately, current investment amounts and energy prices are holding back the widespread use.

Data from several livestock farms prove that the biogas that can be produced satisfactorily covers the energy needs of the farm, and even allows the sale of plus energy, allowing the generation of plus sales revenue.

Very good quality biogas can be obtained from sewage sludge and animal manure, but production involves significant investment and operating costs. The advantage of the process is that the biomass depleted in terms of gas production can be utilized as a valuable soil strength supplement. Biogas from municipal waste can be easily purified to CO and methane content of 98%, which already corresponds to the quality of natural gas, so it can even be fed into the natural gas network. The table below shows the amount of biogas that can be produced from animal manure (Table 1).

Table 1 The amount of biogas that can be produced from animal manure (m3 / t)

type of manure	min.-max.	mean
cattle manure	90-310	200
pig manure	340-550	445
poultry-litter (chicken)	310-620	465
poultry-litter (turkey, goose)	455-505	480
horse manure	200-300	250
sheep manure	90-310	200
manure	175-280	225

More accurate data are difficult to give because the amount of recovered gas depends not only on the feedstock but also on the technology and the temperature of the anaerobic fermentation. The average value in the right-hand column is approx. 75% is recoverable. The following table shows the amount of some biogas feedstocks and the amount of biogas that can be extracted from them (Table 2).

Table 2 Annual quantity of produced biogas

type	quantity (million tons)	produced biogas (billion m3)
animal manure	31	1.4
municipal organic waste	2.5	1.2
municipal sewage sludge	0.2	0.08
slaughterhouse waste	0.4	0.05

Why it is worth to build up a biogas works (Figure 9):

- Use of biogas reduces greenhouse gas emissions
- Increase the economic activity of the countryside
- Saving resource, because biogas is produced through the decomposition of organic matter
- Anaerobic treatment can be improve the quality and spread ability of slurry
- Biofertilizer is a more effective soil improver than untreated manure because it has a better carbon-nitrogen ratio, thereby for the plant is easier to absorb nitrogen
- Reuse of the waste material
- Fermentation reduces the amount of pathogenic bacteria (eg coli, salmonella) and the germination of weed seeds
- It is need a less chemical manure and pesticides
- They contribute to the spread of eco-friendly technologies
- In addition, thermal energy is also generated beside of electricity generation, which can be used on the spot

Figure 9 Biogas works

Biogas is usually burned in a gas engine (Figure 10) after purification. The products of the biogas works are the following:

- Electricity (based on legislation - electricity produced using biogas is taken over by electricity providers at a higher price than conventional electricity.)
- Thermal energy (local solutions must be found for its utilization, e.g.: heating of industrial and agricultural buildings, covering technological heat demand, possibly heating of residential buildings)
- Organic manure (for soil humus capacity replacement)

Figure 10 Biogas engine

The following conditions must be taken into account to select optimal site for a biogas works:

- There should be a sufficient amount of continuously available biomass (it is come from several sources, from which a waste mix, “cocktail” can be made)
- Have a high proportion of high-energy waste
- Availability of sufficient water

- Proximity of the electrical network backbone

For choosing an optimal site of a biogas works, it is worth considering the data in the following table in terms of biomass and other waste. (Table 3)

Table 3 Ideal location for a biogas works based on the availability of basic materials

waste	transport distance (km)	yearly quantity
Liquid manure	0	20.000 m3
Slurry manure	10	25.000 t
Slaughterhouse waste (3. class)	30	15.000 t
raw sludge from wastewater (2% dry matter content)	0,5	10.000 m3
other waste (food production, restaurant)	15	6.000 t

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Summary

Sustainability is doubtlessly a popular word of our time. Defining it is highly dependent on the context. In rural and agriculture development it is a key issue too. Sustainable agriculture can cover the issues of multifunctionality, the use of organic farming methods, ambition towards soil conservation and biological balance through advanced landscape management. Renewable energy resources must be integral elements of such approaches. Beyond popular forms of renewables (hydro, solar or wind), some specific types are more tied to agriculture.

Hybrid systems (combined solar and wind utilities) adjusted to local micro-climatic conditions may support farms almost all-year long. Geothermal instruments are capable of providing heat for foil tents and greenhouses, additionally may guarantee water supply for animal husbandry too.

Biomass is the most adaptable renewable energy form as by-products of agriculture can be a proper base of them. In some cases, special bioenergy plants can be economic main products too. At the same time, biomass burning can be harmful to the environment, but through biogas fermentators they may be harvested in a clearer form.

Self-checking open questions

Describe the meaning of multifunctionality in agriculture!

How would you describe sustainability from an agricultural point of view?

What methods can support a sustainable farm?

What barriers can lessen the realization of different renewable energy-based projects?

What type of energy needs occur in agriculture, in general? How about the branch you are active in?

Describe the main types of solar energy harvest?

In what forms can wind be used in agriculture?

What are the main advantages and disadvantages of hybrid systems?

Trace a possible form of use of geothermal energy in agriculture!

What kind of biomass forms can be differentiated?

What are the advantages and disadvantages of the different biomass-based renewable energy resources?