

approach. End-of life cycle of photovoltaic modules becomes more and more important in analysis of long-lifetime of the photovoltaic systems. It was shown that this approach should be taken in consideration for choosing the optimal photovoltaic system also.

EN_13.1. Comparison of renewable energy systems

Due to energy price increases and uncertainties in natural gas supply and in price trends, furthermore, in many cases, as a result of outdated and inefficient energy solutions, a great number of municipal governments, companies and households seek new ways of satisfying their energy needs. We have a number of examples to support the fact that a carefully planned and well-considered renewable energy utilization strategy would contribute to offering renewable energy as an alternative to conventional energy sources.

According to the National Energy Strategy, solar energy use has promising potentials but the actual realizable energy production is not in line with the high costs and fluctuating availability of devices. The accuracy of the aforementioned statement was investigated by Dióssy and Tóth (2011) who made a comparison between several alternative power plants in terms of performance and investment costs (Table 21). The authors determined life-cycle performance for a period of 25 years for large-scale power plants without having regard to the utilization of the heat generated. With respect to biomass power plants, they calculated with 200,000 MWh, while in the cases of wind plants and photovoltaic plants, these figures were 38,858 MWh and 27,940 MWh, respectively. The study is also concerned with the comparison of fuel oil or gas power stations and nuclear power stations in terms of performance and cost price.

Table 21: Comparison of life-cycle cost of different renewable energy plants.

Type of Power plant	Investment	Generation life-cycle cost			Total input	Unit cost of 1 kWh of energy (euro)
		Type of fuel	Employee remuneration	Maintenance		
		one thousand euros/MW				
Wind power plant	1440	0	185	458	2083	0.0501
Biomass power plant	1812	7260	643	1700	11415	0.0571
Photovoltaic power plant	1831	0	63	120	2014	0.0723

Source: Dióssy-Tóth (2011) p. 16.

With regard to the costs incurred, it is important to note that in photovoltaic systems total direct costs account for 90% of the costs incurred by the investment. This means that profitability may increase with inflation and the decrease in the price of photovoltaic modules may also constitute an argument for investment. During their useful life, photovoltaic modules or photovoltaic systems do not require fuel or lubricant in the conventional sense. Maintenance implies the activity of keeping the area in the proper condition, furthermore, it may also involve the replacement of any damaged component parts. Manufacturers provide a 10-12-year manufacturer's warranty and a 25-year performance warranty whereby

maintenance costs are only minimally integrated into investment costs. Costs for employee compensation imply only a minimal amount to be paid for any administrative work necessary for operating the plant and for the guarding of the power plant site. Maintenance costs incurred by large power stations (especially cycle power plants) are higher than those of small-scale household power plants.

Considering national-level data, from among renewable energy sources, it is wind power that is considered to be the most economical alternative. However in Hungary, the uncertainty of availability and regulatory environment represent issues of concern.

In the case of biomass power plants, conversion of combustible biomass into energy proves to be favourable, although, the proportion of biomass-related costs is higher than those incurred by wind and photovoltaic plants. Transportation needs of basic materials, low transportation efficiency and basic material supply risks all raise doubts about large-scale power plant installations. Investments costs attached to small-capacity power plants (below 5 MW) are high and during their useful life these plants allow only limited access to exploitable profits.

In terms of cost per unit of energy produced, the highest electricity generation cost is assigned to photovoltaic power plants (0,0723 euros), even though solar plants operate more efficiently than power plants run on coal, gas or oil fuel. Converted to HUF (calculating with the exchange rate as of December, 2011), the unit cost of 1kWh of electricity generated by a coal-fired power station is 25.23 HUF while this value is 25.74 HUF per unit/1kWh for gas-fuelled power plants and oil fuel-fired plants generate 1kWh/ 31.96 HUF per unit cost. Unit electricity cost for nuclear plants is merely half of the unit cost for the cheapest alternative energy, however the latter has a higher level of public acceptance.

In the Southern Transdanubian Region, based on the natural resources present in the region, several industrial plants were established which utilize energy from geothermic, biomass and solar energy for their operation. The use of thermal water for the purpose of heating is prevalent in Szigetvár, Szentlőrinc and in Bóly, while solar energy is typically used in Sellye, biogas production takes place in Kaposvár, Kaposzecskső, Bicsérd and in Bonyhád. Utilization of renewable energy sources was investigated by Buday-Sántha (2013) primarily through methods of economic analysis.

Table 22: A comparison of industrial plants in the Southern Transdanubian Region with regard to alternative energy utilization.

	Kaposzsekcső	Bóly	Szigetvár	Sellye
Equity capital	178,042	237,470	894,061	182,514
Financial resource for the project (in thousand forints)	640,953	389,536	400,000	273,771
<i>Total investment cost (in thousand forints)</i>	<i>1,186,951</i>	<i>627,006</i>	<i>1,294,061</i>	<i>456,285</i>
Operational costs (in thousand forints)	270,291	25,129	173,339	20,496
Operating revenue (in thousand forints)	165,015	68,500	177,909	24,842
Output (in thousand forints)	- 105,276	43,370	4,570	4,346
Revenue-based proportional income (%)	-	63.3	2.6	17.0

Source: Based on p.52. of the economic analysis by Buday-Sántha, (2013)

The biogas plant in Kaposzsekcső was inaugurated in spring, 2013. Generation of biogas takes place in an area of 1.7 ha. by using containers, each having a volume of 2500 m³. The energy generating capacity of the industrial plant is 0.83 MW, which is transmitted to E.ON. According to the calculations of the biogas plants, 1m³ biogas generates 1.8 kWh of marketable electricity and 5,5 MJ of thermal energy.

In Szigetvár and Bóly the municipal governments have been long concerned about the issue of geothermic energy utilization. Due to EU assistance funds, implementation work has already been started. The total cost of the Bóly thermal project is 50% of the operating costs of the Szigetvár plant. In Szigetvár a number of concerns are raised by system operation but town leaders spoke out in favour of giving support to the utilization of thermal water.

Investment analysis performed from a financial aspect reveals that it is the solar power plant (Sellye) that proves to be the least capital-intensive investment. Table 22 shows that the availability of the financial resources offered by the project is an essential factor of implementation since almost half (in Szigetvár one third) of the total investment cost was derived from these funds. In Kaposzsekcső it was necessary to obtain bank loans but repayment obligation contributed to a major deterioration in output. On the basis of efficiency, the estimated rate of return for investments: 10.6 years in Bóly, 84.6 years in Szigetvár and 25.3 years in Sellye. If we look at the projected useful life of investments, we can conclude

that solar PV parks generally see their return within their 25-year useful life, which is also true for thermal water utilization. As for Bóly, we can calculate on a 40-year life-cycle and in the 11th year the power plant will be capable of generating a significant revenue.

Dombi (et al. 2012) investigated the sustainability of projects relying on renewable energy sources. In their model they considered air pollution-related values, land use requirements, the positive impacts of job vacancies and those of local income-generating capacity. They analyzed solar energy utilization for six different types of technologies, in the categories of solar modules, large-scale PV system, mirror and focusing technology; PV module for the supply of institutions; green-field solar installation and solar collectors. Land requirement by solar projects is 0.01 – 1.29 ha/GWh while values for carbon-dioxide emission range between 252.9 – 2857.2 t/GWh depending on the type of system applied. In the rank order of relevant technologies depicted by the study, projects targeting solar energy utilization are given great prominence: ranked in the 3rd, 7th, (and 11th, 16th, 20th,) places from among the 23 technologies analysed.

The most favourable sustainability value was ascribed to the Greenfield solar system (of 2200 modules): 0.241, which means a capacity of 0.5 MW and 0.62 MWh of generated energy at investment costs amounting to 330 million HUF.

The above investigations confirm the statements by Németh (2012) who points out that arenas for competition are constituted not only by the rivalry between the types of fossil and renewable energy utilization but also by the solutions to utilizing individual renewable energy sources (such as pellet burning, contemporary-style wood heating, heat pumps, solar-impulse landing gear - solar panels, wind generators and wind power plants etc.). Choice from among the alternatives and decisions made by consumers or investors are influenced by several factors relating to specific solutions: the measure of incidentally necessary investment, the trends in annual costs incurred, level of convenience associated with devices and availability of support schemes. In addition to all the above, investments are affected by several other factors which cannot be or can hardly be quantified.

In his study, Németh (2011) draws attention to the fact that for the purpose of managing resources more efficiently and in an economically more feasible manner, it is reasonable to adopt a complex systems approach to energy investments or carry out their implementation (preferably) in a number stages. The issue of energy saving implies a number of steps to be taken towards observing some factors, such as free arrangements, attention to the close environment (e.g. attention to the reasonable use of light sources, decreasing heating temperature by some degrees without causing any change in the sense of comfort, attention to reasonably reducing the number of events for opening windows). On grounds of expedience, energy efficiency measures are expected to precede modernization of installation technology. PV installation used as a replacement for the electricity supply of individual constructions is feasible to be combined with internal lighting upgrades as, in this way, the electricity requirement of certain constructions - in line with the necessary solar capacity requirement - may considerably become modified.

EN_13.2 Summary of social conditions

Preference for renewable energy sources is important not only because of the growing demand for energy but also because, according to the total life-cycle analysis of energy-producing installations, the environmental burden of the burning of fossil fuels is much heavier (air