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UTILIZATION OF NEW AND RENEWABLE ENERGY SOURCES IN HUNGARY
- RESULTS AND PROGRAMMES -

Transmitted by the Government of Hungary

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I. INTRODUCTION

1. Hungary can be ranked amongst the countries of medium energy consumption. In accordance with the UN statistical yearbook of 1976, the energy consumption per capita was in Hungary 83 GJ surpassing somewhat the 71 GJ/capita world average.

1/ Central Institute for the Development of Mining; 2/ Ministry of Agriculture and Food; 3/ Research Institute of the Electrical Industry; 4/ Institute for Building Science; 5/ Institute for Electrical Power Research

2. The energy consumption has been increased by 37 per cent between 1973 and 1978, which means an annual increment of 5 per cent. However, in the last two years the measures aimed at the energy saving reduced the increment in energy demand to a minimum. In the energy balance of Hungary the share of the coal amounts presently to 27 per cent, that of the oil and natural gas 40 per cent and 24 per cent, respectively; the use of nuclear energy is expected to start by 1982. In Hungary, the fossil energy-resources are moderate; 50 per cent of the primary energy demand is covered from import resources. The increases in the price of energy, particularly that of the oil, have sensitively affected our foreign trade balance which entails great burdens on our national economy.

3. In these circumstances, it is of interest for Hungary, taking into consideration the geographical location and climate conditions of the country, to make use of new and renewable energy sources in addition to the more rational use of energy.

4. Apart from governmental authorities the relevant engineering and research institutes, the Academy of Sciences, the different departments of universities and educational institutes as well as the industry and bigger plants are dealing with the elaboration of tasks aiming at the more rational use of energy. The research projects dealt with by the different institutes are coordinated by competent state organs.

5. The government considers the task of the solution of present and future problems in energy management as a complex one. One part of the problems can be solved by administrative and economic means, while an other part needs further long-term research activities and there are still a couple of questions in rest, which could be answered by

the utilization of significant financial funds in addition to the existing mental capacity.

6. Considering the geographical location and climate conditions only three of the new and renewable energy sources can play role in Hungary. These are:

- geothermal energy
- solar energy
- biomass energy

7. Among these the utilization of the geothermal energy started in the year 1963 and projects aimed at the increased use of this energy are based on the experencies obtained in the past years. The research relating to the conversion of solar energy into direct electrical energy started in 1970. In addition to the geothermal energy and solar photovoltaics, for the utilization of solar thermal energy and biomass energy programmes had been prepared for the next 5 or 10 years.

8. This document gives a concise review of results and programmes.

II. UTILIZATION OF GEOTHERMAL ENERGY /THERMAL WATER/ IN HUNGARY

(a) Discovery

9. At the beginning of the nineteen-sixties, discovery and utilization of geothermal energy together further research for hydrocarbon enabled determination and details of depth of national thermalwater reserves.

10. Details on geothermal resources of the Pannonian Basins in Hungary and adjoining countries and the role of the electromagnetic induction methods in geothermal investigations were discussed at the Seminar on Technologies related to New Energy Sources, Jülich /Fed.Rep. of Germ./[1,2].

11. In the two typical reservoirs /sediment and cracked limestone/ nearly 5,000 km^3 thermal water is available of which depending on the expertise employed, 50-500 km^3 can be exploited. For this study a capacity of 300 km^3 was taken into account as a main value. One hundred years has been estimated for the exploitation of 300 km^3.

12. The exploitable 300 km^3 thermal water reserves mentioned above are situated in an area representing two-thirds of the country, the most significant in the southern part of the Great Hungarian Plain. This area can be considered as the centre of geothermal energy exploitation and of utilization of the country.

13. Theoretically the existing 415 wells can yield annually only about 5-6 per cent /166.10^6/ of total exploitable water quantities.

1/ T. Boldizsár, "Low and medium temperature geothermal resources of the Pannonian Basins in Hungary and adjoining countries", Seminar on Technologies related to New Energy Sources, SC.Tech./SEM.7/ R.3 /1980/.

2/ A. Ádám, "Relationship of electromagnetic induction to tectonophysics"..., Seminar on Technologies related to New Energy Sources, SC.Tech. /SEM.7/R.6/ Add.5 /1980/.

(b) Utilization

14. Apart from baths of Roman and Turkish origin, widely developing during recent decades, planned and widespread utilization of geothermal energy has started by the year 1963. In addition to earlier utilization the most important sectors for utilization have been agriculture and specifically horticulture. As a result: today, Hungary has the greatest number in the world of horticultural greenhouses with geothermal heating /0.7 million m^2/ that means 80 per cent of greenhouses producing vegetables. In addition 1.2 million m^2 greenhouses with foil are also heated by thermal waters, animal husbandry plants /poultry, pigs/, rough fodder- and cereals drying equipment, and a refrigerator prototype.

15. Geothermal heating and warm water supply equipment are already used in more than 3,000 apartments /incl. public institutions/.

One hundred and thirty-five thermal water baths /in addition to those in Budapest and public medical Baths/ with a capacity for 200,000 persons means facilities for approximately one-third of the total population.

16. For the time being, 23 per cent of the heat-content and 20 per cent of the water discharge of thermal waters of high temperature discovered to date and suitable for heating have been utilized.

17. Geothermal energy utilized for heating annually replaces 60,000 tons fuel oil with a value of nearly 300 million forints.

18. Investment costs of thermal-well /up to 2,000 m depth/ are

identical with those of a boiler plant of the same capacity, with fuel oil firing, but with additional costs for a pumping plant and accessories and necessary radiator heating surface.

19. Benefiting from past experience, the fundamental technical problems concerning the chemical origin of thermal waters have been solved in the majority of instances /scale deposit, corrosion, degassing, etc./. Technical developments and the establishment of prototypes of technical equipment to meet special requirements have permitted the widespread utilization of geothermal energy in the public sector and agriculture.

(c) Prospective developments in the next decade

20. In the next decade, ever increasing lack of water and energy must be taken into consideration on a global scale.

21. In connection with lack of water, special emphasis is laid on deep-seated water reserves which are practically unexploited to date. Regarding energy, the accumulated heat content of the earth is estimated to be commensurable with that of carbon and hydrocarbon reserves. In this relation research and development projects are now in hand at the international level.

22. Hungary has launched, for the coming decade, a development programme with the following tasks:

- increased practical utilization of the already known thermal water reserves and of geothermal energy; and at the same time,

- adaptation to domestic conditions of international research aimed at increased utilization of thermal energy from the earth, in addition to thermal water as a heat-carrier with the application of other technical solutions.

23. Utilization of thermal water reserves is already taking place — principally with regard to agriculture and communal services.

(i) Agriculture

24. Utilization possibilities under both winter and summer seasonal conditions are examined.

25. In past years, widespread utilization of geothermal energy was commenced in the field of agriculture /horticulture, animal husbandry, various drying, refrigeration systems, mushroom-growing etc./; and this is of decisive importance not only in Hungary but also internationally. Taking these facts into considerations it is suggested that the greatest possible amount of geothermal energy be used in the development of horticulture. On this basis it would be possible between now and 1990 to increase the present 70 ha greenhouse and 120 ha foil covered greenhouse surfaces by 100-200 ha and 100 ha, respectively. At the same time this could improve the vegetable supply, result in large savings in energy, and increase export possibilities.

26. In order to increase vegetable supply in Hungary only by 1 kg/capita, 10,000 tons forced vegetable would be required which can be produced in 100 ha greenhouses. The result of the suggested horticultural development would be as follows:

- 1 ha greenhouse can produce 100 thousand kg primeur or deliver plants for 25 ha primeur hardy cultivable land;

- 1 ha foil covered house deliver plants to 100 ha hardy bulk good production.

27. Considering saving of energy, the heating of 100 ha greenhouse and 100 ha foil covered greenhouse requires annually 60,000 and 30,000 tons fuel oil, respectively. The greatest amount of heat energy required to drying, canning and preserving equipments can be covered by geothermal energy, as well.

(ii) Communal services

28. Concerning thermal water supplies and geothermal heating of housing estates and public institutions, new housing estates to be built up to 1990 are a very promising possibility. Of the approximate figure of 1,5 million new apartments envisaged between now and 1990 almost 800,000 are on a territory where thermal water and geothermal energy have been discovered and utilized. For the 10-15 per cent of these apartments, the utilization of thermal water mainly for warm water supplies can be considered.

29. The utilization of thermal water is important primarily from the aspect of communal water supplies. One hundred thousand apartments need 15 million m^3 water annually. Considering that within one household 80 per cent of water requirements concern warm water /for bathing, washing, and cleaning purposes/ warm water supplies could reduce consumption of cold water by 15-20 million m^3 and overloading at water works.

(d) Advantages

30. Advantages are the fact that the specific expenses involved in increasing water capacities are lower with regard to thermal water; generally lower production costs for 1 m^3 water; and energy savings.

31. The heat requirement for an apartment is about 63 GJ annually of which 42 for heating and 21 for warm water. To supply 100,000 apartments with warm water yearly $2{,}100.10^3$ GJ are required which can be secured by geothermal energy. For the production of this heat energy 60,000 tons of fuel oil would be necessary.

32. Thermal waters with a temperature over 70 C^o can be economically applied to the heating of apartments and institutions. Geothermal heating equipment established in 1966 in Szeged /country town in South-Hungary/ on the 'Ogyessza' housing estate/ is able to achieve the heat requirements of nearly one thousand apartments by the utilization of a thermal well of 90^{o}C temperature and 90 m^3/h water discharge. This value could presumably raise significantly by application of heat pump equipments, top-boiler plants /on new housing estates/ and local exploitation possibilities.

33. The utilization of thermal water and geothermal energy in towns and on housing estates is of great importance for environmental protection. Warm water supplies by means of thermal-water in winter time reduces the application of other energy-sources causing air pollution; and in the summer season it is unnecessary to keep boilers in operation for warm water supplies. Combined solution of heating- and warm water supply meets the requirements for most clean heating system. Problems involving colour, taste, odours in household supplies /characteristic of certain thermal

water types/ can be solved by suitable water treatment.

(e) Economic efficiency

34. The financial aspects of water and geothermal energy to be utilized until 1990 will not be calculated since up to 1990 both investment and saving costs-factors /cf. oil prices/ could be distorted. Also to be taken into consideration is that the provision of water and energy will be a matter of greatest interest in Hungary and all over the world in the course of the decades to come and initial costs will be of only minor importance.

35. There are various factors on the basis of which the utilization of thermal water and geothermal energy can be evaluated.

(i) Charges for investment

36. Based on the data of utilization equipment, the investment cost of equipment supplying geothermal energy up to 13 GJ/h is the same as the construction costs of fuel oil plant of same capacity. When output is greater, investment costs for production of geothermal energy rise depending on locational circumstances.

37. Using thermal water for domestic warm water supplies, the installation costs change between 40-100 per cent compared with those of cold-water supplies.

(ii) Operational costs

38. Operational costs of 4 GJ range between 30 and 100 forints

for geothermal heating equipment presently in operation depending on the type of equipment. For example the cost of supplying 4 GJ with fuel oil or natural gas can be estimated to have an average value of 300 forints. Thus, if the construction of geothermal energy supply equipment were to involve more expenses than those of a boiler plant, the surplus expenses would be amortized in a very short time.

39. Operational costs of 1 m^3 of thermal water range between 1.20 to 3.50 forints compared with those of cold water supplies amounting to 1.20 to 9.00 forints.

(f) Further advantages

40. Geothermal energy is independent from all external economic, political or transport factors.

41. The quality of deeply located thermal water is not influenced by industrial or any other impurities.

42. Geothermal energy promotes the vigorous development of intensive farming /e.g. the southern part of the Great Hungarian Plain where large-scale development of horticulture has taken place in the course of a few years/. It is extremely advantageous for communal utilization from the point of view of environment protection.

43. Bathing, swimming and medical thermal-bath treatment are of great importance from the social and sanitary aspects. The promotion of tourism and holiday resorts is increased.

(g) Disadvantages

44. The proportion of thermal water reserves that can be exploited has not been universally determined; experts estimate this to be between 1,250 and 250 km^3 /in this study 300 km^3 was taken into account/.

45. Owing to this uncertainty, the quantity of derivable geothermal energy cannot be evaluated with any certainty but, concerning the total energy requirements of Hungary and present-day possibilities, it may amount to 4-10 per cent in the future. Geothermal energy cannot be transported for great distances and therefore only local utilization is possible. Since geothermal energy exploitation specifically requires widespread exploitation of water quantities, the problem of placement arises.

46. In spite of the disadvantages mentioned above, these are outweighed by the advantages accruing from increased utilization of geothermal energy.

III. UTILIZATION OF THE SOLAR ENERGY

(a) Solar energy in photoelectric way

(i) Review of the results

47. In Hungary the scientist has been dealing with the research of the conversion of solar energy into direct electrical energy since 1970. Similarly, to the international research trends the first photoelectric elements were also produced by using monocrys-

talline silicon by which 6-8 per cent conversion efficiency was obtained. By further development of the technology it succeeded to increase the efficiency up to 12-15 per cent. By using these elements several single and complex electrical source were made in a max. output range of some tenth watts and more hundred watts in the last period.

48. Among others, autonomous solar cell electrical power source for telecommunication equipments, buoyage, water pump equipment, telemetric equipments, special measuring instruments were produced.

49. The development of several other photoelectric conversion methods are in progress; experimental samples of the CdS and photoelectrochemical converters were produced. However, the conversion efficiency of several per cents does not make the production of a great quantity economical.

(ii) Ongoing research and development

50. The present work is aimed at developing the complex supervisionfree solar cell electric power sources used for more purposes. This results in a modulus system of about 3 kWh/a and 25 kWh/a performance which makes possible the universal solution of optional tasks. Concerning the measuring technique, the conditions of the internationally uniform qualification system have been established; for this purpose different reference standards have been made and simulators put into operation. In addition to the development of various alternative photoelectric and photoelectrochemical systems, investigations on policrystalline structures are in progress. For example experimental samples of the

silicon polycrystalline solar cells of 10% conversion efficiency have been developed.

(iii) Prospective development

51. According to the prospective developments, investigation of further alternative converting structures has been taken into consideration, primarily the application of those on barrier structures. The conditions for the application of solar cells on larger scale have to be established and to attain this aim, the serial production of photoelectrical structures at optimal i.e. minimal costs has to be solved.

52. In spite of the fact that the results in the physics and application-technique are promising, the conversion of the solar energy cannot compete presently with the conventional power generating systems. For that reason the widespread application of direct conversion has not been envisaged, at present, in Hungary; the solar cell-systems are to be applied only in particular cases, where the energy-supply cannot be secured by the public network.

(b) Outline of the programme relating to the utilization of solar thermal energy

53. Considering the energy balance, the utilization of the solar thermal energy is of much more importance than power generating from solar energy. In Hungary, this is justified on the basis of the relevant radiation data. The results in the application of solar technique obtained on international level and the continuously increasing energy prices made possible and necessary to formulate an extended R+D programme on solar energy.

(i) Objectives

54. According to the programme three different subjects can be distinguished, which aim at the direct application of solar energy in low-temperature region.
They relate to:

- domestic hot water supply for various user groups, i.e. family houses and apartment buildings, utility-, and industrial buildings;

- auxiliary heating and passive systems for apartment-, utility-, and agricultural /husbandry/ buildings;

- auxiliary heat supply for drying and cultivation systems in agriculture.

55. Within the frame of the programme two subjects can be emphasized, i.e. the hot water supply and the use of solar energy in the agriculture.

a. Domestic hot water supply

56. The use of solar energy for hot water supply is of particular interest in Hungary. In the summer season a great part of the energy demand for hot water supply / 75 - 85 per cent / can be replaced by solar energy. This amounts to 10-15 per cent in the winter and between-seasons. That means that taking into consideration an apartment 40-50 per cent of the energy for hot water supply can be saved on the yearly average.

57. It is expected that in Hungary in the year 2000 3.7 million

apartments would be installed with central- or individual heating. In the case, if it succeeded to develop a technical-economic competitive system for the use of solar thermal energy, then 11 per cent of these apartments could be installed with solar energy equipment for hot water supply; the savings on heat energy would amount to 2.10^9 MJ/a in the year 2000 replacing 60,000 t/a fuel oil. That means that in the next 20 years 1.6 million m^2 collector surface would have to be installed for hot water supply.

58. For the time being, the development of flat-plate collectors for making warm water or air is under way.

b. Use of solar energy in the agriculture

59. The energy saving by the use of solar drying seems to be essential. A solar drier silo for producing 550 tons dried hay requires 1260 GJ solar energy in a drying cycle, which could be covered by the use of about 80 tons fuel oil.

60. Bearing in mind, that the valuable internal ingredients of rough fodder start decomposing after being mowed, the loss on nutritional value can significantly decrease and by that a considerable sum of money can be saved.

61. The R+D programme aims at development of systems for active use of solar energy and at development and investigation of structural components, which come up to requirements of the drying technology in agriculture considering the technical-economic aspects and the optimization, too.

62. The systems and system-components of the solar technique are to be developed applying heated air for drying of rough fodder and cereals. If it is necessary the storage conditions and material transport have to be modified, too.

c. Space heating

63. Because of the season-depending solar radiation the space heating can be considered only as an auxiliary heating. In this connection the programme concerns the collectors, the coolant, the short-term storage and the control. In the frame of the programme the integration of the various system-components and the integration of the whole system into the building construction have to be solved.

(ii) R+D activities

64. The programme mentioned above specifies the research and development activities, which are necessary to attain the aims. The activity includes, inter alia

- meteorological data logging, data storage and processing;
- development of measurement technique ;
- research and development of the system-components and integration of the whole system in order to get a technical-economic optimum;
- building construction and components of that with regard to the application of solar energy;
- analysis of the development on the basis of the literature and other information gained on international level;

- methodics of the investigations;
- system-analysis, software subjects.

65. The timing of the programme is divided in three phases, i.e.

- research activity;
- experimental equipment /drafting, construction and checking at least over 1 year/;
- elaboration of product-series.

IV. BIOMASS PRODUCTION AS A CONTRIBUTION TO THE IMPROVED UTILIZATION OF ENERGY RESOURCES

(a) Introduction

66. Of the total land area of 9.3 million ha in Hungary, 6.7 million and 1.6 million ha are suitable for agricultural and forest cultivation, respectively. The energy yield of crop production varies between 20 and 200 GJ/ha depending on species and the ecological conditions. From the field crops produced altogether on 5 million ha, the staple crops yield 60-70 GJ/ha, while their by-products represent an energy value of 35-40 GJ/ha. The annual energy yield of crop production is 1.5 times higher than the total fossil and electric energy consumption of the country.

67. Regarding biomass energy and solar energy, it is of interest to note that in Hungary the natural photosynthesis is the most important way of the utilization of solar energy;

in the case of optimal conditions, it may substantially affect the energy balance of the country, too.

68. A special research group was studying the efficiency of agricultural production in Hungary with the purpose to represent the possibilities for increasing the efficiency and to outline the research subjects which result in a favourable energy transformation system. The input-output analyses have always been carried out by applying an integrated energetical concept, thus all the input and output data were expressed in energy units.

69. Approaches in order to increase the efficiency of energy transformation:

- to improve the effective use and utilization of input energy resources during the given period of time;

- to supplement the traditional energy resources by natural or renewable energy forms;

- to increase the value of output energy by the improvement of the efficiency of biological energy transformation;

- to conserve the quality and quantity of energy produced as much as it is possible and to utilize the main and by-products.

(b) Possibilities to increase the efficiency of the utilization of input energy resources

70. The fossil energy consumption of agricultural production can be decreased to a high extent if modifying the methods of harvest of several field crops /eg. maize/ and that of preservation of products, improving the mechanization and assuring the reasonable air condition of the feedlots.

71. The energy content of the soil, as the basic production resources of the agriculture, can be incresed by amelioration and optimal utilization of industrial feedstocks on one hand, and providing an optimal or at least acceptable hygienic ecosystem for crop production, on the other.

72. In Hungary, the animal protein consumption is relatively high /near to 20 kg/capita /year/. The consumption pattern is based on food production originating from animal husbandry which necessitates an intensive crop production, rather than cattle or sheep meat production utilizing extensive field areas.
The influence of the consumption pattern in order to find a more favourable energy balance is a question of price policy.

73. The feeding and breeding technology must be synchronized: the physiological heat transfer must be compensated by the possible cheapest feedstuffs, while such a housing system should be applied in which the climatic conditions necessitate minimal energy requirements of feedstuff supply.

74. In accordance with the assumption of some scientists about 300-400 GJ biomass energy per ha can be produced under our ecological conditions. A conceptional change would be necessary in defining the purposes of plant breeding, partly regarding the ratio of main and by-products and partly the possibilities of by-product utilization.

75. The technological and technical conditions for the utilization of biomass resources not suitable for feedstuff production /and which is only partly processed/ should be also provided.

76. The plant residues i.e. the by-products of plant production and the organic wastes produced in industrial animal breeding systems can be utilized after different biochemical conversion.

(c) Scope of the research programme proposed

77. In order to increase the biomass production in Hungary a research project should be worked and carried out.

78. The energy content of the different plant species will be measured, and on the basis of this evaluation both plant production and animal husbandry systems will be specialized.

79. The working group suggested to work out the following research programmes:

- to study the more favourable possibilities of utilization of the natural energy resources /biomass production, increase of generical potential, etc./;

- to improve the efficient use of input energy presently available in the production /shift in the production pattern, regional specialization, modification of housing systems, etc./;
- to modify the dietary pattern taking into account the reasonable energy conservation /with particular attention to the position of plants requiring protein import/ ;
- to study the possibilities of improved utilization of energy produced /by-products of plant and animal origin; waste materials of food industry, their utilization etc./.

80. The research project should include the possibilities of the optimal realization of the above goals.

81. On the basis of decision made in the research project short-, medium-,and long-term phases should be outlined including the agro-energetical goals to be performed, that is to say the alternatives of biomass production and utilization which are also effective from economical point of view.

82. Some studies and experimental work connected with the research programme outlined above are already under way, for example:

- some pilot equipments will be set up to demonstrate the direct energetic utilization of biomass by combustion of by-products of plants /straw, corn-stalk and cob/ and by gasification of biomass;
- experiments to produce chemical products from biomass

- biological systems /bacteria, membranes/, which are able - irradiated by light - to produce hydrogen or electrical effects, are studied [3,4]. However, the fundamental research in this field may contribute to solving the energy problems only in the extreme future.

3/ Cs.Bagyinka et al, "Studies on solar energy transduction by halobacteria and thiocapsae", Seminar on Technologies related to New Energy Sources , Sc. Tech./SEM.7/ R.6/Add.3 1980

4/ Á. Faludi-Dániel et al, "Organization of bulk pigments in chloroplast membranes", Seminar on Technologies related to New Energy Sources, Sc.Tech. /SEM.7/R.6/ Add.7 1980