PROPOSAL ON MULTIPURPOSE UTILIZATION OF GEOTHERMAL FLUIDS WITH HIGH CONTENT OF DISSOLVENT GAS AND SURFACE TEMPERATURE HIGHER, THAN 100°C

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The heat flow density[1] and geothermal gradient of the Carpathian Basin is characterized expressive by the favourable endowment of geothermal energy-sources of Hungary (in Fig. 1). Because of this values are between 80 and 100 mW/m^2 higher, than the world average. For example the calculated and measured maximum is: 113 mW/m^2 existing in the closed district of Szeged town (The European average is 62 mW/m^2).

Parallel with the productive carbohydrogen mining in the last centuries, among the more than 8000 prospecting well drillings, in a number of cases and places the results was an "influx of thermal water" fluidum, like a secondary product. Over 3000 wells had been therefore qualified as **"abandoned** (oil) **wells"**, contrary to productive hydrocarbon (oil, earth gas) wells (see Fig. 2) which are shown [2] a the dense places. From these we can choose the multifunctional utilizations – technologies of those wells or group of wells, supported by the basic data of their mining reports, records and preliminary calculations.

In the beginning the utilization of thermal water and springs have been realized in the form of balneological (medical) thermal bath or recration bath in open air pools and by drinking cure of mineral water [3]. The heat energy utilization of thermal fluidum started much later; first in agricultural sphere (in plant cultivation-, horticulture-, stock breeding-, f.e. in poultry-farm, fish-breeding etc.), and after that cam the space heating and sanitary hot water supply; the district heating systems for part of towns and villages in Hungary [4]. The "cradle of such method takes place first in Southern-Lowland-Region (see the Figures 4. and 5).

If they made any comparison between the number of relatively optimal places and the distribution of thermal baths in the regional-spatial structure (see Fig. 5) and the number of selected, well known wells with best parameters – but up to now are not used – and the fresh informations [2] and endowment of recent surveyings, documented in details for 19 counties of Hungary (see Fig. 6) [2], it have to be understood – that **the main task will be in the future to increase the number of thermal heating systems**, instead of supporting the small and immense thermal bathes (with single purpose) in contesting with each other.

In particular it is important to focus on the wells having over of 100°C temperature for complex, multifunctional – in cascade – utilization of thermal energy (with reinjectioned technology).

By all means **the conditions of economical production** (agricultural) and supply (space heating **and energy supply) have to be established**, introducing parallel with environment-protection technologies [8]. Besides the benefit of saving energy in absolute terms on the local level, and by their world-vide application yields the realization of these power plants would decrease the import ratio of energy sources, resulting more independence for the country.

The temperature and the geothermal gradient depend mainly on the depth of tectosphere, the local heat flows, and the thermal conductivity of the rocks. Where the rocks of the base of basin have appropriate productivity and permeability, it **is possible to achive wet steam** production in even relatively shallow depths. In such reservoirs the formation pressure can be more than twice the hydrostatic pressure. [15]. Such reservoirs were mainly karstified carbonate rock or brittle rocks by tectonic [9] and hydraulic breccia formation.

These fluids with medium size enthalpy and higher temperature of depth (90–150^{o}C) overpressure thermal-stock-indications [9], [10], are suitable for electric power generation with ORC (Organic Rankine Cycle) binary system and combined production for the utilization of direct heat energy in cascaded system (the smaller rate for electric power generation using the upper heat content, and higher rate for heat supply) [11], [12], [13].

The effectivity of these viable systems – provided adequate support is given – **can further be improved** where the fluid with big water capacity (2500–3000 m^3/day) – in case of our project – is **in possession of great amount of dissolved gas** as well (15–28000 m^3/day) which have to be separated (de-gasing the primary fluid) any way when applying the traditional way too. This gas engine (basic data on Fig. 7) volume (chiefly methane) is avaible to utilize in small size electric power generation by inserting gas-generators.

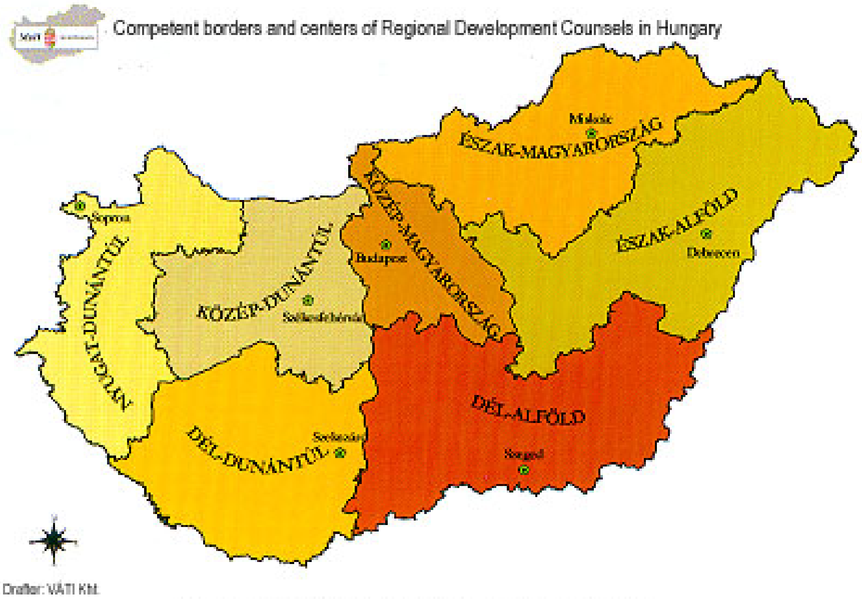

Fig. 4. Territorial border of the 7 Regions of Hungary

The **National Regional Development Concept** [6] approved by the DECISION 35/1998. (III.20.) OF THE HUNGARIAN PARLIAMENT based no the National Regional Development and Physical Planning have an influence no the long term development targets of the country, as it has different background studies for complexity, including the study and **concept for the utilization of renewable energy resources** [7], drawing their optimal territorial structure and recommended distribution of electric power generation sizes and places (see on Figure 3.).

In the frame of the proposed distribution, 12 characteristic areas can be found with the best locations of geological, hydrogeological and regional potentials for building medium size electric power plants (mainly geothermal – based and a few with solar and fusion electric power plants).

A third of these locations fall into the area of Southern Lowland Region (4 characteristic areas here), of which one territory – also found to be best for solar power plants – is defined by the borders of Mélykút, Jánoshalma, Balotaszállás and Pusztamérges (see Map 8.).
Following the oil explorations and the positive opinions of local and foreign experts, already in 1996 a decisions was made to work out a prefeasibility study for the building of power plants based on 5 wells in the region (3 with production and 2 with reinjection functions) with the use of foreign support.[15]

The calculations relating to the first pair of wells (M1, M2) for electricity production, showed water volumes of 30 liters per second while the well group chosen for direct heat productions (M3, M6, M7) was calculated with 60 liters per second. The temperature of the output water is projected to be 155 degrees Celsius while for the latter group it is 101^{o}C.

Based on the technical calculations and estimations, the installed electric capacity of the Mélykút-Balotaszállás **geoelectric power plant is 1.0–1.3 MW** (2 X 735kW), and its **heat production 21.5–30.0 MW**. This energy would be utilized on one hand by supplying it to the existing medium-sized voltage network (20 kV), on the other hand it would be channeled to the agricultural-greenhouse and municipal-communal and small enterpreneur heat consumer-group in form of district heating system (heating + sanitary hot water). In addition, the current planning team is working out a solution whereby **the significant amount of gas disolved in the water** (main data in Figure 7.) would – after sufficient separation – be used in parallel with the ORC system for the production of **electric energy produced by a special gas generator**. According to preliminary calculations the output would generate an additional 0.2 – maximum 0.35 MW. The selection of the gas generator is currently underway. The schematic connection diagram can be found on Figure 7. [15], [16]

The economic calculations of the prefeasibility study (1996) which we referred to are outdated. These need to be made actual, due to the promotions given to domestic combined energy transformations and energy derived from renewable resources. The small and medium-sized power plants are expected to become in general competitive. In our case - based on the positive parameters of the Mélykút power plant (with extended functions) especially the reimbursement period is reduced to an acceptable value, even if the internal installations of the extended functions would be newly built, thus increasing the investment costs and other additional expenses.

The operational **conditions of the local small powerplants are positively influenced by the nearness of receiving electric** main and medium-size **distribution networks** and their abilities for energy transportation. For the purpose of receiving small electric power, the medium-size voltage distribution networks **(20 kV)** are sufficient, while for larger volumes access is needed to the national main distribution network **(120 kV)** (see Figure 9. and 10.). [14]
In case of Mélykút-Balotaszállás, partially the 20 kV networks, originating from the Kiskunhalas and the Szeged 120/20 kV transformer stations are sufficient for receiving the smaller power volumes calculated thus far.

Conditions for realization

The calculations of the prefeasibility studies were up till now based on expert estimations and hypothesis which should not be replaced by the followings:

- exact measurable data,
- **exact measurable** geological, geophysical data, which have get first from the production wells, with suitable shaping of opencast part of wells,
- **layered examination** of wells, getting exact data of temperature, output volumen and chemical composition of fluid. This important work needs a special "research-fund", which can borrow enough money for investigators in the very beginning period it means, relatively high risk-volumen because it cost of 20–60 millio florin per well. (40000–120000 EU):
- measurement of well potentiality and the conditions of local reinjection mode,
- definition of the rate of salt and different gas volumens [1] and its treatements,
- wells-modicifation for reinjected function, and definition of repressuring parameter
- exploitation and reinjection flow of fluid have to be originate and operate continously [1]
- feasibility study for geothermal-electric power plant,
- getting approvals and licences of the outhority,
- assessment of heat consumers,
- organization of the necessary tender and its performance,
- preservation of the operation and supply of power plant.

Recommendation: The realization of the **presented small power plant** which is designed for such a region with special characteristics would be an excellent **reference** and would have motivating effect on the developers of other regions as well, especially since there has not yet been any geothermal power plant built in Hungary up till now. Based on the well-known potential endowments, **another 50 plants** with similar output capacity **could be established in Phase I. until 2015** (in total resulting in 100–300 MWelectric + min. 1500 MWheat). This solution would improve the volume of renewable energy-resource utilization in addition to **improving** also **the ratio within the national energy resource structure**, thus reducing the percentage of import needs.

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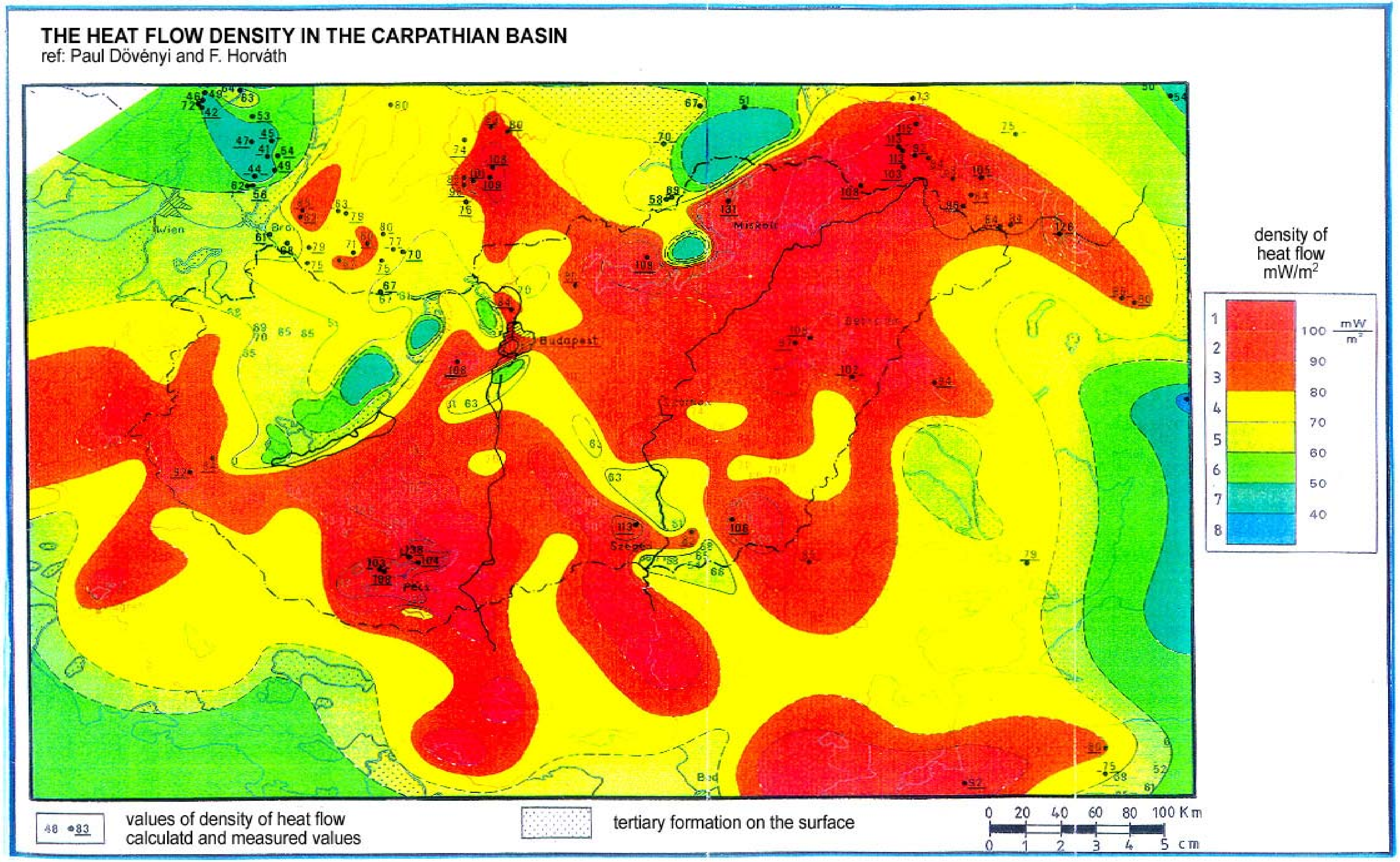

Fig. 1. REGIONAL DISTRIBUTION OF THE HEAT FLOW DENSITY ON THE CARPATHIAN BASIN [1]

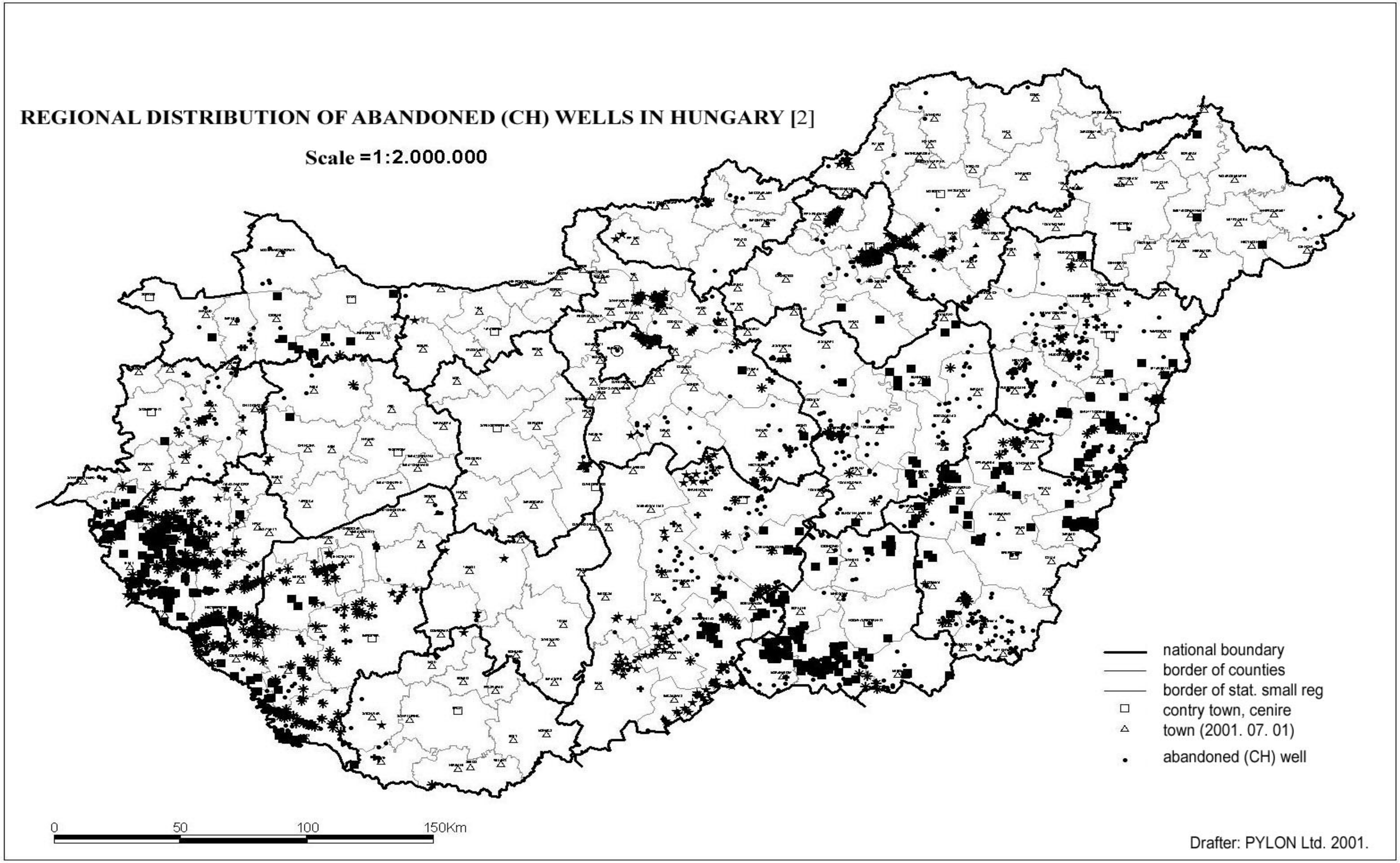

Fig. 2. REGIONAL DISTRIBUTION OF ABANDONED (CH) WELLS IN HUNGARY [2]

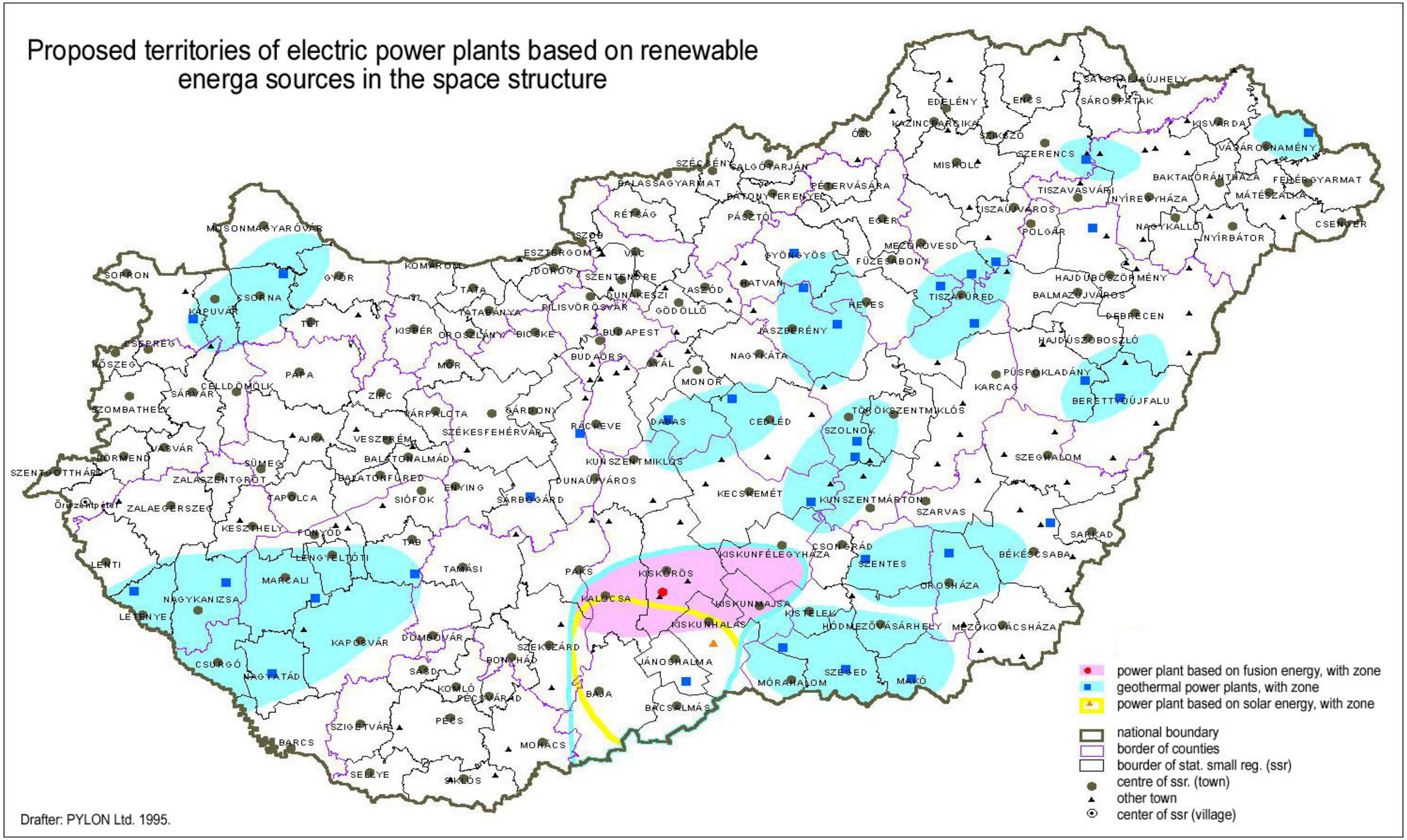

Fig. 3. ENHENSED REGIONS FOR THE PROPOSED GEOTHERMAL POWER PLANTS IN THE SPACE STRUCTURE OF HUNGARY FOR A LONG TIME [6] [7]

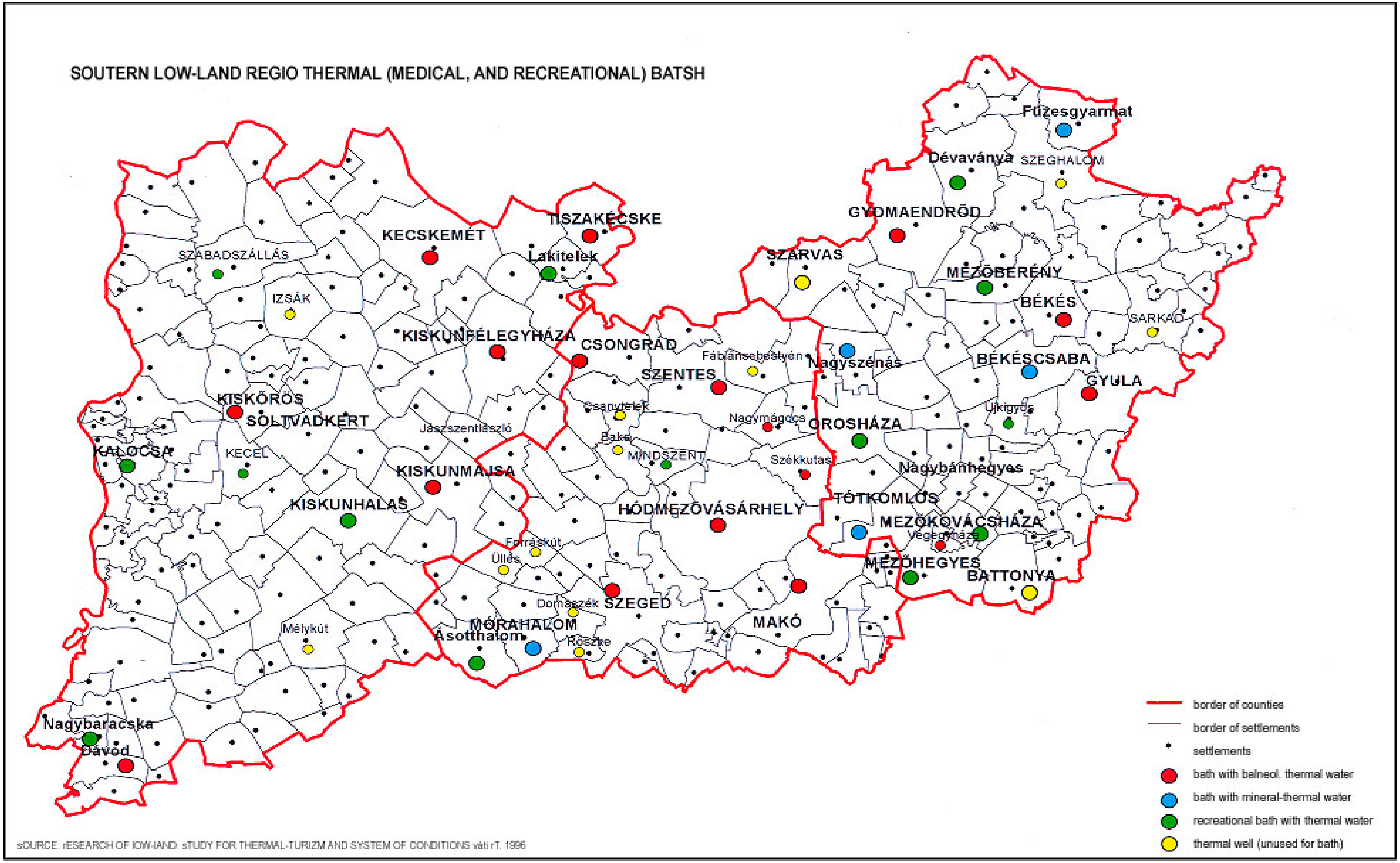

Fig. 5. SOUTHERN LOW-LAND REGIONS WITH EXISTING THERMAL WELLS AND THERMAL - BATSH PLACES DISTRIBUTION [4] [5]

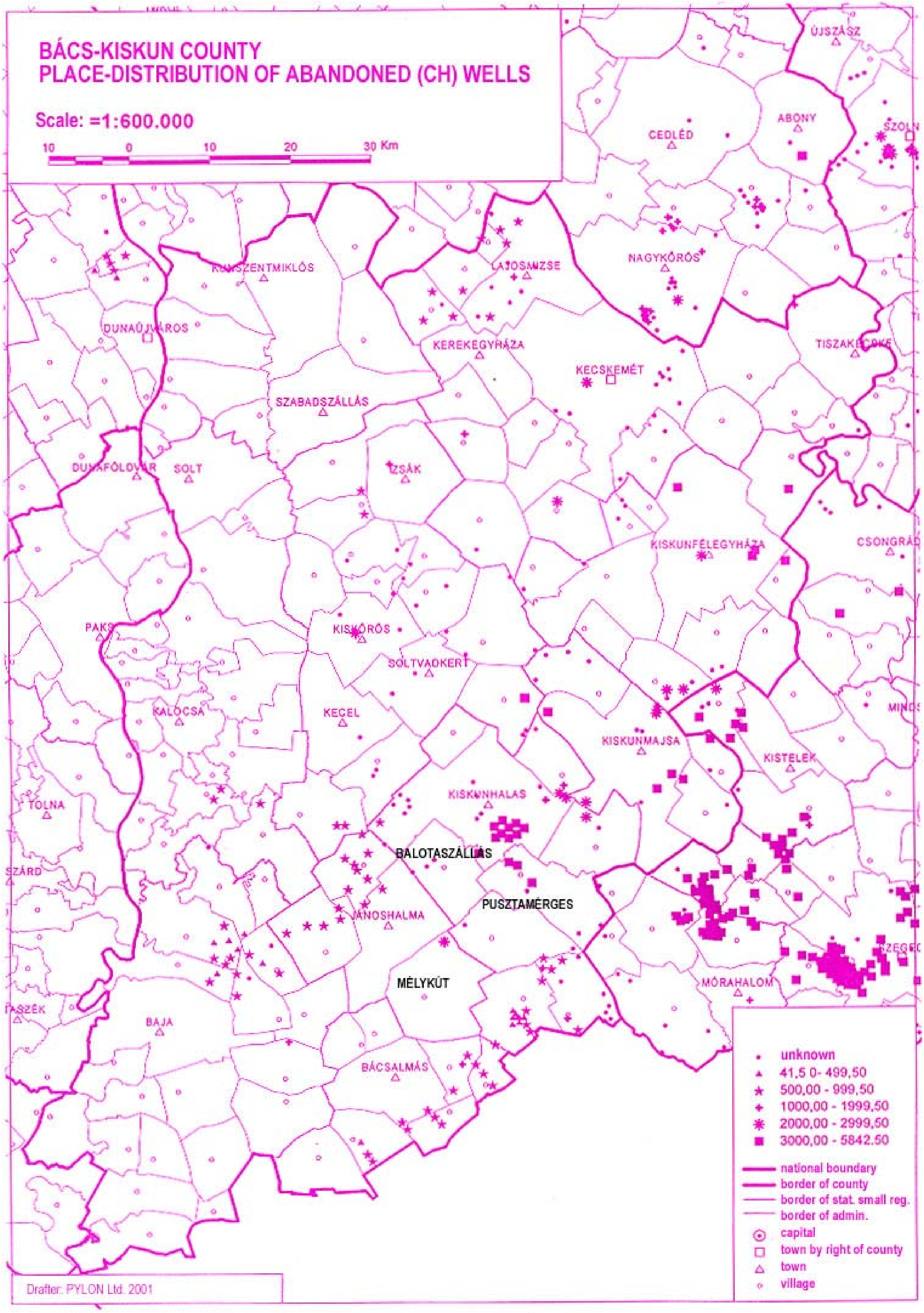

Fig. 6. ABANDONED (CH) WELLS OF BÁCS-KISKUN COUNTY [2]

Volumen of dissolved gas: 15000 m^3/nap
(γf=0,1 MPa)
Rate of gas-water(GVV): 4,84 (5,6)

composition of dissolved gas (without O2)	m^3/m^3	g/n.m^3
C_1	0,498 (0,8267)	356,8 (592,2)
C_2	0,01098	14,88
C_3	0,00359	7,25
N_2	0,04161	92,05
CO_2	0,44569 (0,1234)	881,13 (243,96)
gasolin no exists	(2,19)	
density relative	1,015 (luft)	0,703
absolut	1,312 g/l	0,909
combustion heat kJ/m3	20948	35953
heat contens kJ/m3	18898	32452
Content of O2	nincs	nincs

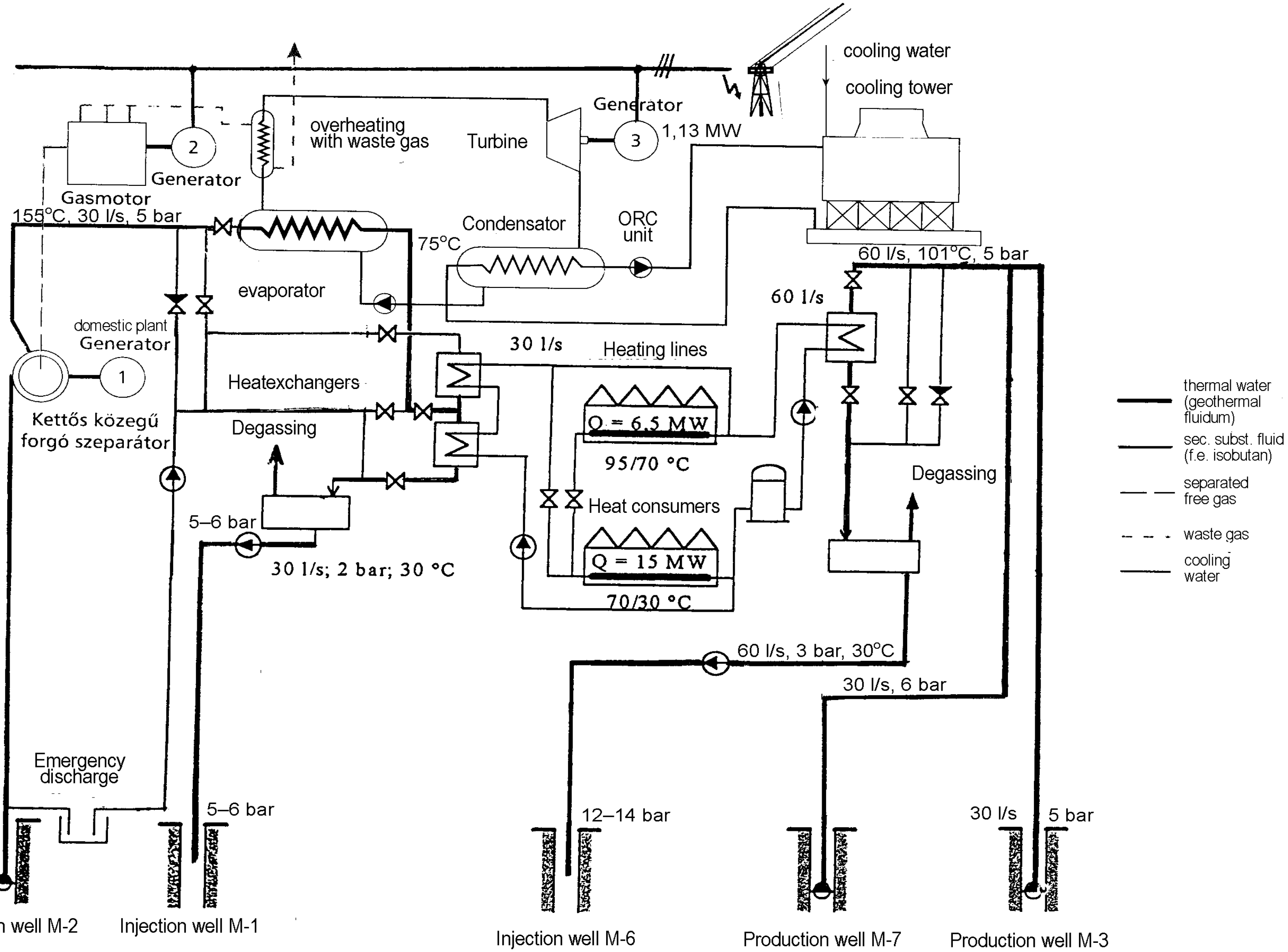

Fig. 7. SOUTHERN LOWLAND REGION - Mélykút - Balotaszállás - Pusztamérges.
Schematic, symplified diagram for the cascaded use of geothermal electric and heat power plant [15]

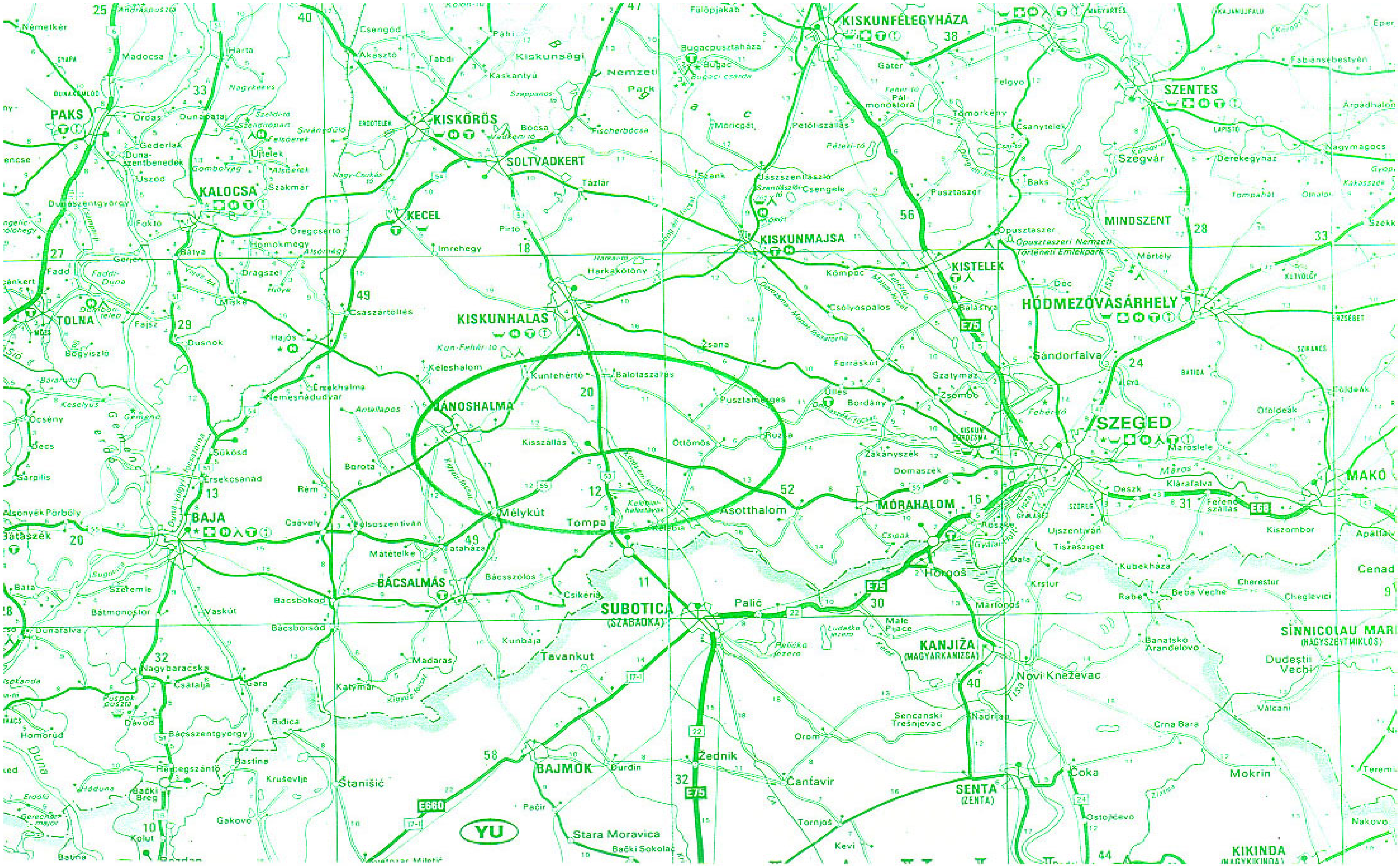

Fig. 8. GENERAL MAP FOR SUGGESTED PLACE OF GEOTHERMAL POWER PLANT IN MÉLYKÚT - BALOTASZÁLLÁS - PUSZTAMÉRGES ZONE

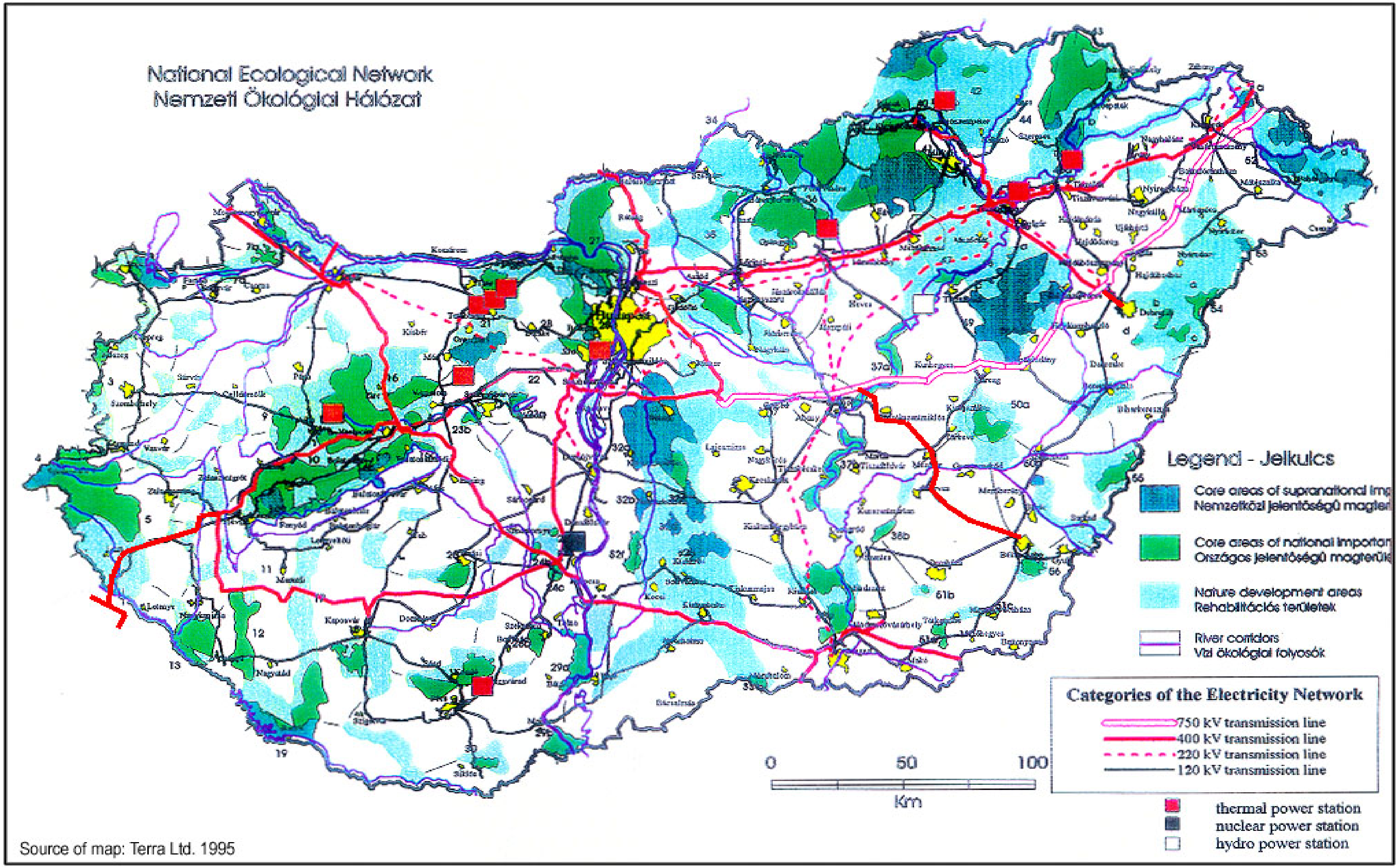

Fig. 9. NATIONAL AND INTERNATIONAL ELECTRIC NETWORK-SYSTEM OF HUNGARY ON THE NATIONAL ECOLOGICAL NETWORK MAP [14]

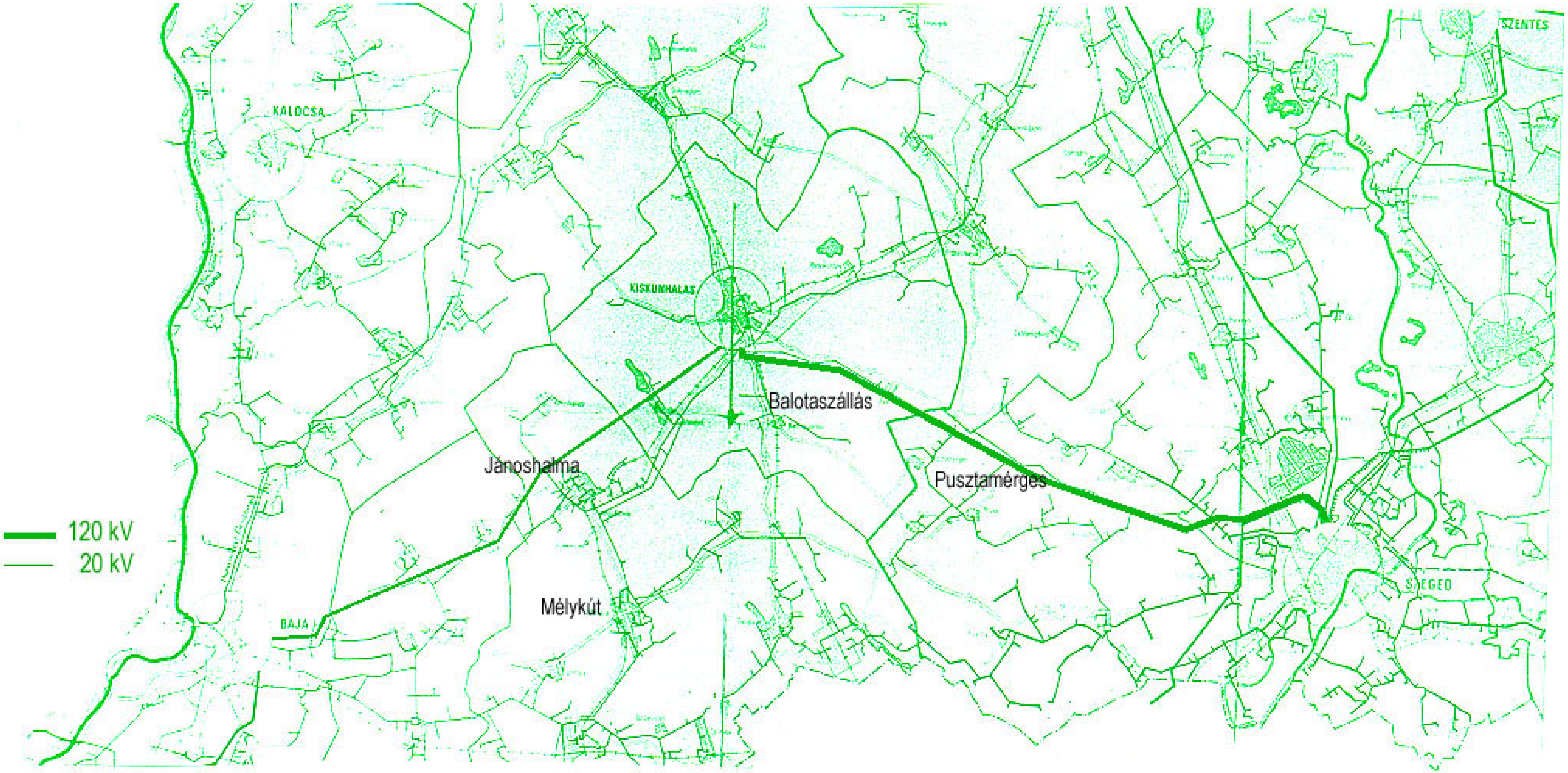

Fig. 10. ELECTRIC MAIN DISTRIBUTION AND MEDIUMVOLTAGE-DISTRIBUTION NETWORKS IN THE ZONE OF PROPOSED GEOTHERMAL POWER PLANT