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Overview of market drivers and best practices

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CONCERTO

GEOCOM

Overview of market drivers, fiscal measures and subsidies

Deliverable D6.2

Overview of market drivers and best practices

Mineral and Energy Economy Research Institute
of the Polish Academy of Sciences, PAS MEERI (WP6 leader)
and the GEOCOM Partners

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Contents

Introduction

The presented Report forms Deliverable D6.2 resulted from the realization of Workpackage WP.6.3 titled “Overview of market drivers, fiscal measures and subsidies” in frame of the EU-Project “Geothermal communities – demonstrating the cascaded use of geothermal energy for district heating with small scale RES integration and retrofitting measures” (GEOCOM).

The following seven countries were covered by WP6.3 works and this Deliverable D6.2:

- Macedonia,
- Hungary,
- Italy,
- Poland,
- Romania,
- Serbia,
- Slovakia.

The work was done with the contribution of all GEOCOM Project Partner teams and appointed experts, coordinated, interpreted and summarized by the Mineral and Energy Economy Research Institute of PAS team, WP6 leader.

1. Objectives of research works

The objective of Workpackage WP6 was defined as “developing a better understanding on the public perception of geothermal energy, overview of socio-economic market drivers, fiscal measures and incentives”. It has been composed of three parts:

- WP6.1 “Public perception of geothermal energy”,
- WP6.2 “Public perception and understanding of RUE measures (pilot-site case studies)”,
- WP6.3 “Overview of market drivers, fiscal measures and subsidies”.

In particular, Workpackage WP6.3 “Overview of market drivers, fiscal measures and subsidies” – the results of which are presented in this Report – aimed at identification of essential factors and conditions (existing or absent) that control the geothermal energy development and related rational use of energy in particular GEOCOM countries. The constraints were to identify while existing best practices were to be recommended to transfer among the countries. The work was conducted taking into account wider background of renewable energy sources sector and its state-of-the-art in particular countries.

2. Basic factors influencing market development of geothermal energy uses in the GEOCOM countries

In the GEOCOM countries (as is the general case of many other states), economic activities connected with renewable energy sources and geothermal development are parts of wider national and regional economy so are also affected by general economic situation both at the international as well as at national levels. As another important factor one shall point out the essential role of country and regional energy policies /strategies related to RES, geothermal which results from international, EU- and country documents and directives.

Furthermore – essential is the role and share attributed to particular RES' types in national laws on renewable energy sources (RES) and National Renewable Energy Action Plans (NREAPs) in particular countries – specially that the EU-members and other European countries are responsible to decide the share of particular available RES and support measures and incentives to meet their indicative RES shares in final energy consumption by 2020. In respect to geothermal energy, its share and role envisaged by these kinds of documents, its role and percentage contribution are small (not exceeding several %; see also D6.1) despite large and prospective resource base.

In case of geothermal energy its minor role in official EU and state strategic documents results in generally weak financial conditions for geothermal uses development, shortage of measures and incentives which would be tailored / dedicated to its specifics. Existing incentives and support measures are in majority of cases available in frames of wider systems / programs addressing RES sector as well as enhancement of economic activities, job creation (small and medium entrepreneurs, SMEs). These are funded by national and EU-programs. This fact is justified by current situation in prevailing number of the GEOCOM countries.

3. Research on market drivers, economic measures, and selected environmental conditions for geothermal energy development in the GEOCOM countries – scope and methods

3.1. Scope and aspects covered by the research

In frame of WP6.3 the following groups of issues related to geothermal energy uses' development in the GEOCOM countries were investigated:

- Financial constraints (on capital investments, flow of capital, and other);
- Environmental constraints and considerations:
  - Land concessions (vs. geothermal drilling, exploitation, constructing, operation of geothermal installations),
  - Water rights - specially in the view of spent geothermal water's injection,
  - General aspects of economic viability and cost-effectiveness of geothermal projects in relation to avoidance/reduction of CO_2 emissions (carbon footprint reduction),
  - Sustainability issues in a financial context (i.e. sustainable long-term exploitation of geothermal reservoirs which is possible mostly in case of injection of spent geothermal waters), especially with regards to the need for injection vs. total environmental costs of disposal of spent geothermal waters into surface water streams).

3.2. Research methods

The following research methods were applied to meet the WP6.3 objectives and goals:

1. Questionnaire interview survey on governmental / public financial constraints and measures dedicated to geothermal energy development in the GEOCOM countries.
For these purposes the targeted selection of respondents' group was applied; there were the Experts (appointed earlier in frame of WP6.1). The Questionnaire results were also helpful for Foresight survey results' interpretation and served as inputs for General Matrix as well as were applied to make general comparison among particular countries.
The scope of items covered by the Questionnaire was as follows:

- Financial resources – governmental / public support for geothermal projects:
  - Investment subsidies,
  - Feed-in-tariffs, green certificates / certificates of origin,
  - Conducive payback and tax regulations (flexible depreciation of geothermal investments, favorable tax treatment for third party financing, start-up subsidies for new production plants),
  - Start-up subsidies for small – medium entrepreneurs (SMEs),
  - Subsidies / tax regulations for new job creation,
  - Fiscal measures for consumers to purchase geothermal equipment and systems,
  - Other financial measures available for investments (banks, private sector, other forms);
- Environmental, water protection, sustainability constraints / issues;
- Regulations on /obligatory/ injection of spent geothermal waters;
- Water rights – requirements related to geothermal water exploitation/injection.

2. Qualitative methods – description of basic factors and constraints for geothermal energy development in the GEOCOM countries.

That investigation was done for several issues common for all countries, collected and described by the Experts (similar like in case of quantitative questionnaire survey). The objective was to gain qualitative information and feedbacks on fiscal and financial support tools, legal provisions, environmental, water rights, injection issues and constraints for geothermal energy development in individual Project countries. For such a set of input information (Annex 1, Annex 2), which supplemented the Questionnaire and Foresight method results, PAS MEERI team conducted its general summary and applied their results to give a comparative insight into the situation in particular countries and in general (e.g. existing similarities and differences among the countries, market situation of geothermal energy, etc.).

This information was accompanied by the lists of main legal acts and regulations that control and refer to geothermal water and energy exploitation and use (in the view of particular group of items described or treated in the Questionnaire). Long lists of various acts (Annex 1) have indicated how complex is formal legal and administrative environment that affects geothermal energy development in the Project states.

3. Foresight methodology approach – it was based on the structural cross-impacts analysis and the input created by the Matrixes of Influences filled up by the experts representing all GEOCOM countries.

Typically, foresight instruments are applied to actively create development in the future (usually in the perspective of several decades). In these GEOCOM works there were employed some of its elements to identify basic factors that might affect the future geothermal energy uses development and rational energy use – main subject of the mentioned Project.

(More details on foresight methodology, applied method and results are given in section 4.5).

Among the outcomes of the performed research is the **General Matrix** which indicates market drivers and brakes (fiscal measures and subsidies) for geothermal energy development existing or absent in particular GEOCOM countries. The Matrix was based on the information delivered by the Questionnaire survey and qualitative information done by the GEOCOM partners and experts. It formed a basis to indicate the best measures and the best practices which shall be recommended or transferred to other countries.

4. Results of research

4.1. General circumstances of geothermal energy uses' development in the GEOCOM countries

On the basis of feedbacks received from the Experts (who were involved in the WP6.3 Questionnaire survey, screening the existing circumstances and constraints, Foresight survey) one may illustrate the general situation for geothermal energy uses' development in the GEOCOM countries as follows:

- The RES sector (and its geothermal element) is affected by international and country economic recession taking place in many states in recent years. This fact has resulted in rather limited amount of public sources dedicated for RES sector development (and geothermal in particular) specially when it coincides with weak or stagnated country economy (e.g. of Hungary);
- Unstable, frequently changing legal and economic environment related to RES policy does not favor the development of geothermal industry (despite good prospective natural resources, e.g. in Hungary, Poland). To give some particular example: in case of Poland there has been no fundamental law on RES put in force so far (in February 2015 it was under proceeding by the Parliament) which would regulate also economic aspects of RES-oriented activities (despite the EU requirements). Works on it were prolonging (having been ongoing for several years). In such situation, potential entrepreneurs are therefore careful and do not take investment activities (specially in geothermal sector oriented for space heating and other energetic uses);
- Even if – in reference to some countries – one can generally state that there are no specific financial constraints for initiating of geothermal investments since favorable conditions are generally offered to entrepreneurs (e.g. Macedonia), on the other side – there are no dedicated financial incentives for investment in geothermal heating plants and systems (specially subsidies for drillings) and none for power generating facilities. Similar situation is observed in case of more specific laws and regulations: e.g. assuming that geothermal power plant would be connected to the grid the common laws should apply since there are no preferential tariffs for the energy of geothermal origin;
- In all the GEOCOM states the general financial mechanisms were established at governmental and prevailing cases also at regional levels for the purpose to support the RES' sector deployment (specially in order to meet the 3x20% goals and national energy strategies). They are in forms of grants, credits, loans, tax credits. As a rule they prioritize the RES electricity generation and RES types other than geothermal, also when RES heat development is concerned. Another issue is that these funds are usually limited, specially for geothermal, and are mostly dedicated to develop the above-surface infrastructure – while in cases of all other RES this is correct, but in case of geothermal investments the crucial, most expensive and risky parts are subsurface installations and objects, including drilling the wells and in these respects the available financial support is very limited or even none. Also – no Geological / drilling risk funds were established so far and only in one case (Italy) such tool is considered to be introduced (e.g. Italy).

In subsequent subchapters 4.2 and 4.3 a review of selected financial, environmental factors and constraints which control geothermal energy uses development in the GEOCOM countries are presented. They give an insight into situation in particular states, allow for some comparisons and ease to suggest which good measures and solutions (when existing in some countries) could be recommended / transferred to other countries which are missing such proper tools.

4.2. Financial support for geothermal projects – availability and constraints. General Matrix

On the basis of information derived from the WP.6.3 Questionnaire survey, qualitative information and feedbacks delivered by the Experts, a General Matrix was composed. It gives an insight into current state of financial support (fiscal measures and subsidies) for geothermal projects in the GEOCOM countries. If existing, such tools act as market drivers for geothermal energy development. Short summary of the Matrix is given in table 1, while table 2 presents its full version (i.e. with details on specific financial measures in use). General Matrix served also for comparisons and was helpful to recommend or transfer the best measures which facilitate geothermal deployment from one to another Project country. Furthermore, it was also a part of considerations using the concept of foresight method (subchapter 4.5). Further in this subchapter the situation in respect to particular considered measures was described and compared among all Project states.

Table 1. Financial support measures and constraints for geothermal energy development existing or absent in the GEOCOM countries – summary of the WP6.3 Questionnaire survey's results

Country	Hungary	Italy	Macedonia	Poland	Romania	Serbia	Slovakia
Fiscal measures							
Conducive playback and tax regulations, including:							
- flexible depreciation of geothermal investments	No	No	No	No	No	No	No
- favorable tax treatment for third party financing	No	No	No	No	No	No	No
Fiscal measures for consumers to purchase geoth. equipment and systems	Yes	Yes	No	Yes (heat pumps)	No	No	No
Financial subsidies*							
Investment subsidies	Yes	Yes	No	Yes	No	No	Yes
Start-up subsidies for new production plants	Yes	No	No	No	Yes	Yes	No
Start-up subsidies for SMEs	Yes	Yes	Yes	Yes	Yes	Yes	No
Subsidies/ tax regulations for new job creation in RES / geothermal sector	Yes	Yes	Yes	No	No	Yes	No
Other financial subsidies							
Feed-in-tariffs (for electricity)	Yes	Yes	No	No	No	Yes	Yes
Green /other certificates	Yes	Yes	No	No	No	No	No
Other financial measures for investments (banks, private sector, other forms)							
Other financial tools for investments (banks, private sector, other forms)	Yes	No	Yes	Yes	No	Yes	No
Financial measures dedicated for drilling and operation of geothermal wells							
Subsidies for geothermal drillings	Yes	No	No	No	No	No	No
Geological risk insurance fund (short, long term)	No	No	No	No	No	No	No

* *Financial subsidies for the items other than drilling the wells*

Table 2. General Matrix indicating financial supporting measures – market drivers (fiscal measures and subsidies) and constraints for geothermal energy development existing or absent in particular GEOCOM countries (based on the WP.3 Questionnaire survey, qualitative information and feedbacks delivered by the experts). By green highlighted are best practices cases which can be recommended to other GEOCOM countries where proper measures are missing (see also section 4.4)

Country	Hungary	Italy	Macedonia	Poland	Romania	Serbia	Slovakia
1	2	3	4	5	6	7	8
Fiscal measures							
Conducive playback and tax regulations, including:							
- flexible depreciation of geothermal investments	No (Depreciation is calculated in line with standard depreciation calculation procedures)	No	No	No	No	No	No
- favorable tax treatment for third party financing	No	No	No	No	No	No	No
Fiscal measures for consumers to purchase geothermal equipment and systems	Yes Subsidies available for private individuals for thermal insulation, change of windows and doors, for heat pumps' installing. They are sporadic and cannot keep up with the demand. The subsidy rate is 50%	Yes **Lower VAT-10%** (instead of 21%) to connect to a DH network and buy and install GSHP **Contribution to DH network connection**: 20,658 €/kWt, reduction on income tax of natural persons of 36 % (until 30 June 2013 it was 55%) of connection costs **Fiscal credits on heat sold by RES DH network**: 0,0258 €/kWh and 10% VAT **Contribution to GSHP**: reduction on income tax of natural persons of 50% of total costs	No	Yes In some regions possibilities in case of GSHP purchasing and installment Subsidies and support for thermal retrofitting of different types of buildings	No	No	No

Tab. 2. cont.	Hu	It	Mac	Pl	Ro	Se	Sl
Financial subsidies							
Investment subsidies for geothermal projects	Yes *ERFA* funding is available for public and private entities. The maximum contribution is 50%. (this funding is very much sought after, most calls are open for a day or two before being closed due to the high number of applications)	Yes Heat: - *Tax credit*: 20% of investment costs in geothermal or biomass DHs - *Incentive for DHs' end-users* – to connect to main pipeline - *Kyoto Fund:* also finances shallow geothermal installations (GSHPs?) of capacity < 1 MW_{th} - *Other possible regional measures* – to support investments. Most are EU structural funds (i.e. FERS, regional funds). *National Guarantee Fund for new DHs*: yet to be implemented Electricity: Some cost reimbursement of implant for final users	No	Yes Subsidies for above-surface infrastructure /regional, EU-funds/ specially for heating infrastructure /some percentage of total costs. No subsidies for investment part related to drilling the wells and connected items – *the crucial constraint!* (such ministerial fund operated by 2012 /max. 50% of exploration well drilling and related works/. Closed due to decision of state chief geologist	No	No	Yes *Environmental Fund* (Min. of Environment): Heat and hot water preparation through low CO_2 emission and RES uses; Heat and hot water preparation and electricity generation through RES use for natural persons - *EU Structural Funds (2007-2013):* Operational Programs – "Competitiveness & Economic Growth", "Environment" (CHP installations, PV, small-scale hydropower plants, heat pumps
Start-up subsidies for new production plants	No - As above: subsidies available in a number of forms but these are not specific to geothermal or RES sector – no such subsidies or tax exemptions are available specifically for RES sector	No	No	No	Yes In frame of Economical Competitiveness Operational Fund	Yes Provided by Government of AP Vojvodina	No
Start-up subsidies for SMEs	Yes - Start up subsidies are available from government sources and local authorities (municipalities) - Possible exemption from a start-up with high employment potential from some local taxes but this is not at all specific to the RES sector	Yes - From EU structural funds and national /regional sources	Yes - Short-term programs available for geothermal as for any kind of SMEs' business start-up (i.e. not particularly dedicated for geothermal)	Yes - Short-term programs available for geothermal as for any kind of SMEs' business start-up /in case of geothermal – address the activities related to stages other than conc. subsurface installations /incl. drilling the wells/	Yes	Yes - Start-up subsidies for SMEs are (available for geothermal sector) provided by Government of AP of Vojvodina and by Ministry of Finance of Republic of Serbia	No

Tab. 2. cont.	Hu	It	Mac	Pl	Ro	Se	Sl
Subsidies/ tax regulations for new job creation in RES / geothermal sector	Yes - As above: subsidies available in a number of forms but these are not specific to geothermal or RES sector – no such subsidies or tax exemptions are dedicated to RES sector specifically	Yes - Under tuning a new governmental law for improving employment of younger people	Yes - Same as above	No	No	Yes - As a part of previous (new production plants and SMEs subsidies)	No
Feed-in-tariffs	Yes **For RES electricity**: Complicated system as one would expect differentiating between the source of electricity (RES, waste, combined) as well as between the times of feed-in etc.	Yes **Thermal Feed-in-Tariff:** for small size RES heat production only (e.g. GSHP), it lasts 2 yrs (if P≤35 kWth) or 5 yrs (if P>35 and ≤1 MWth) and covers up to 10% of predicted costs **FiT for geothermal electricity production**	No	No	No	Yes	Yes **For RES electricity** - Feed-in-tariff: to support **RES-E** since 2009. Governmental acts set mandatory purchase of RES- E until specified fix output, for various RES. FiT for geothermal plants (planned): - in operation before 1.1.2010 and in 2010 (*theoretical*): 195,84 €/MWh x coefficient (depending on the year of construction) - in operation in 2011: 195,84 €/MWh - in operation after 1.1.2012: 190,51 /MWh
Green /other certificates of origin	Yes There is a number of certificates /incl. green/ but very few are generally used or accepted. All new buildings must have **certificate of energy consumption.** Certificate system is now used as investment subsidies, *e.g.: an investment can be eligible for subsidy only if the classification of the building affected changes from C to B category (this is just a general example not an actual case)*	Yes **Green Certificates**: for DHs connected to High Efficiency CHP; for electricity production in CHP coupled with DH **White Certificates**: for DH and DHW production using GT heat and for GSHP with a high energy saving potential (not cumulative with other government incentives)	No **No green certificates for RES/geothermal heat** (Green certificates for RES electricity (not applicable for geothermal – no such plants))	No **No green certificates for RES /geothermal heat** Certificates for RES-electricity but the system will be changed /project on RES Law in prep.; be.g. 2014/	No	No	No

Tab. 2. cont.	Hu	It	Mac	Pl	Ro	Se	Sl
Other financial measures available for investments (banks, private sector, other forms)							
Other financial measures available for investments (banks, private sector, other forms)	Yes *However,* Banks, private investors offer investment loans but these are not specific to RES / geothermal sector	No	Yes Loans with lower interest rate for application of energy efficiency measures and RES / geothermal	Yes - Loans with lower interest rate for geothermal drillings and subsurface parts available at some banks, and for surface infrastructure, energy efficiency measures and RES *- Some dedicated national and regional programs granting subsidies for thermal retrofitting, introducing RES into some kinds of public buildings (not incl. deep geothermal, drillings, etc.)*	No	Yes Bank credits and private investments	No
Financial measures dedicated for drilling and operation of geothermal wells							
Subsidies for geothermal drillings	Yes Currently these activities are supported from the Structural Funds, experts urge the implementation of the German system where the amount of funding received /drilled meter is the function of the target depth and investors may receive a flat rate of 200€/kW for the built-in geothermal output capacity as a one-time subsidy	No	No	No	No	No	No
Geological risk insurance funds (short, long term)	Planning phase, please check out the Hungarian dimensions of the IEE project GEOFAR (http://www.geofar.eu/) and refer to the GEOFAR reports	No	No	No	No	No	No

As results from table 1 and table 2, in respect to existing financial support measures for geothermal energy development in the GEOCOM countries, relatively the best situation is in Hungary (8 types of measures are existing from among total number of 12 covered by the WP6.3 Questionnaire and qualitative surveys) and in Italy (6 from among 12). From the other hand, the worst situation is in Romania and Slovakia (only 2 types of measures are existing from among 12 concerned in table 1). Looking at all seven Project countries, in 29 cases investigated measures are existing for a total number of 84 potential cases (i.e. ca. 34 %). This shows that general situation is far not satisfactory.

Further in this subchapter the situation in respect to particular considered measures is described and compared among the Project states.

Fiscal measures

- *Conducive payback and tax regulations* such *as: flexible depreciation of geothermal investments; favorable tax treatment for third party financing* are not existing in all GEOCOM countries in case of geothermal energy sector.

- *Fiscal measures for consumers to purchase geothermal equipment and systems:*

In four GEOCOM countries these measures are also not existing. To some extent they are available in three countries: Hungary, Italy and Poland.

In Hungary the subsidies (50% rate) are available for private entities (natural persons) for installing the heat pumps – including geothermal ones (ground sourced-heat pumps, GSHPs). These subsidies are also for costs connected with increase the energy efficiency, i.e. for thermal retrofitting, change of windows and doors, etc. However, the subsidies are sporadic and cannot meet demand.

In Italy the fiscal measures are relatively the best developed and fitted to the specifics of geothermal energy (compared with other GEOCOM countries) and available in various forms:

- Lower VAT - 10% (instead of standard 21%) to purchase and install geothermal heat pumps (GSHP), and to connect to a district heating (DH) network (as most efficient heating type, based on any energy source (traditional, renewable),
- Contribution for DH network connection: 20,658 €/kWt, reduction on income tax of natural persons of 36 % (until 30 June 2013 it was 55%) of connection costs,
- Fiscal credits on heat sold via district heating networks based on RES (incl. geothermal):
0,0258 €/kWh and 10% VAT
- Contribution to GSHP: reduction on income tax of natural persons by 50% of total costs

In Poland the subsidies are available (in some regions) to purchase heat pumps (all types), including also geothermal ones (GSHPs). These measures are parts of wider regional programs supporting purchasing and installation of small RES equipments and systems (solar collectors, heat pumps) by individual and some public entities. One may expect that geothermal heat pumps will obtain more support from regional / local funds soon, since in case of relatively low capacities (below 100 kWt) they are regarded as micro-installations (subjects of interest of the-so-called prosuments) and as such will be promoted by new Energy Law (expected to enter into force in the near future; 2015).
As in almost all the GEOCOM countries, several subsidies are available (at regional or state levels) for activities dedicated to thermal retrofitting of buildings (public, private, tenants organizations, communities, etc.) and to energy efficiency's increase.

Financial subsidies

Investment subsidies

Some investment subsidies are existing in four countries: Hungary, Italy, Poland and Slovakia.
No such measures are available in Macedonia, Romania and Serbia.

In Hungary the funding from European Regional Development Fund *(*hun. *Európai Regionális Fejlesztési Alap, ERFA)* is available for investments that promote application /installation of renewable energy sources (including geothermal), the investments that promote their application/installation. The maximum subsidy (contribution) is 50%. This funding is very much sought after, most calls are open for a day or two before being closed (due to the high number of applications). However, the intensity of such financial support is lagging far behind compared to best performing European countries in this regard. In addition to that it does not take into consideration local specifications and in many cases they end up at other parties rather than the one which actually produces the renewable energy.

One shall also point out that the heat generated from renewable energy sources is not subsidized at all (as is the case of several other GEOCOM countries, e.g. Poland).

Besides the costs of the actual investment there are a number of other expenses which further increase the installation costs of renewable energy sources. In particular, natural gas price is heavily subsidized by the state, generating very distorted proportions. Low gas price doesn't make any other alternative a viable and economic decision.

In Italy, in case of geothermal heat sector the following measures are offered:
- Tax credit: 20% of investment costs in geothermal (or biomass) district heating systems (DHs),
- Incentive for DHs' end-users – to connect to main pipeline,
- Kyoto Fund: finances part of shallow geothermal installations (GSHP) of capacity < 1 MWth,
- Other possible regional measures to support investments come mostly from the EU-structural funds, i.e. European Fund for Regional Development.

Moreover, the National Guarantee Fund for new district heating systems (DHs) is considered (yet to be implemented). If introduced it will embrace also geothermal district heating systems.
In case of geothermal electricity sector (including cogeneration, CHP), some cost reimbursement of implementation for final users is available.

As for geothermal DHs, except for possible regional incentives, most of financial support measures are for end-users, national financial support for investments (only 20% tax credit on investment) is limited and inadequate. Regional incentives change depending on the region: some region may support investments in new plants (through guarantee funds, co-financing, long term agreement with ESCOs, etc.), some other do not.

In Macedonia, in general there are no dedicated financial incentives for investment in geothermal heat plants/systems, neither power generating facilities (even if there no key constraints). To give an example: if geothermal power plant would to be connected to the grid the common laws would apply since there are no preferential tariffs for the energy of geothermal origin.

In Poland, for geothermal investments (heating sector) some subsidies related to the above-surface infrastructure, specially for heating infrastructure are available from regional or EU-funds. However, no subsidies for investment part related to drilling the wells and connected items – this is the crucial constraint for geothermal energy uses development (since high upfront investment expenditures specially for drilling works - which form main part of total investment costs. Specific fund of the Ministry of Environment and operated by the National Environment Protection and Water Management was operational by 2012 /max. 50% of exploration well drilling costs and related works/ but it was closed due to decision of state chief geologist.

In Slovak Republic heat and hot water preparation through low CO_2 emission's sources and RES uses (this means also though geothermal energy uses) and RES electricity generation for natural persons is subsidized by the Environmental Fund* (established and operated by the Ministry of Environment).
The EU Structural Funds (2007-2013) – two Operational Programs "Competitiveness & Economic Growth", "Environment" offered subsidies for small-scale RES installations like photovoltaics, small-scale hydropower plants, and heat pumps (incl. geothermal ones). The beneficiaries were: self-governing regions, municipalities, state and public administration, private companies.
Investment support is expected from Structural Funds in new programming period (2014-2020).

** Environmental fund (established under the authority of Ministry of Environment of the Slovak Republic) is composed of financial sources coming from environmental penalties and supplements collected in the economy. At the moment the fund is supporting only non profit projects meeting social needs through the following activities:*
A/1a, A/1b: Heat and hot water preparation through low CO_2 emission and RES use
A/1c: Heat and hot water preparation and electricity generation through RES use for natural persons.

However, in case of RES / geothermal heat there is no financial support/subsidy scheme in Slovakia for investments in small-scale heat pumps (and/or shallow geothermal systems) used in households (family houses). Similarly, heat produced in geothermal heating plant connected to the grid is not supported.

Start-up subsidies for new production plants

Start-up subsidies for new geothermal production plants are reported from Hungary, Romania and Serbia.

In Hungary these subsidies are available in a number of forms (as for some other economic enterprises) but they are not tailored to the specifics of geothermal energy (or RES).

In Romania one may apply for the subsidy for geothermal plants in frame of Economical Competitiveness Operational Fund

In Serbia (Autonomic Province of Vojvodina) the subsidies for new production plants may be provided by the Government of this Province.

Another issue is that these subsidies have been not really used so far, except for Italy, since so far in prevailing number of cases geothermal electricity has been not generated yet – it is anticipated in the near future and these subsidies will be used, too.

Start-up subsidies for SMEs

These tools are part of wider governmental economic policies to support economic activities of SMEs in various branches of business and economic activities. As such they generally address also geothermal / RES sectors but are not specially tailored to their specifics. These measures are known and reported from five the GEOCOM countries: Hungary, Italy, Macedonia, Poland, Serbia (AP Vojvodina). They can be available via governmental, local / regional authorities sources and / or from

EU-structural funds (provided if some investor would be interested in starting relevant geothermal project and apply for this type of subsidy).

In Hungary start-up subsidies are available from the sources of government and local authorities (municipalities). It is possible to obtain an exemption from a start-up with investments of high employment potential from some local taxes (but this is not at all specific to the RES sector, as mentioned above).

In Italy start-up subsidies are granted from EU structural funds and national /regional sources.

In Macedonia short-term programs are available for geothermal as for any kind of SMEs' business start-up (i.e. not particularly dedicated for geothermal).

In Poland short-term programs are available for geothermal as for any kind of SMEs' business start-up /in case of geothermal – address the activities related to stages other than concerning subsurface installations /including drilling the wells/.

In Serbia start-up subsidies for SMEs are available for geothermal sector provided by Government of AP of Vojvodina and by the Ministry of Finance of Republic of Serbia. Provincial Secretariat for Science and Technological Development for several years gives subsidies for establishing new production capacity, based on the application of new technologies, to the extent of 49% of the value of the investment. For the purposes of the Financial Plan of the Provincial Secretariat for Science and Technological Development funds are planned in the amount of 245,000,000.00 dinars (approximately 2 million Euros) in the year 2015.

Subsidies/ tax regulations for new job creation in RES / geothermal sector

As in case of start-up subsidies for SMEs, also these tools are part of wider governmental economic policies. One can make use of them also in geothermal / RES sectors but, as before, they are not specially tailored to them. These general measures are operational in five GEOCOM countries: Hungary, Italy, Macedonia, Poland, Serbia (AP Vojvodina).

Other financial measures

Financial subsidies in forms of feed-in-tariffs and certificates of origin

In four out of seven GEOCOM countries: Hungary, Italy, Serbia, Slovakia, the Feed-in-Tariff (FiT) systems were introduced to enhance RES electricity generation. In case of geothermal sector they are in use in Italy (geothermal power generation has been ongoing there for decades /in the area of Montieri pilot site, Larderello /Tuscany) while in remaining three countries they were recently introduced to encourage potential investors, enhance research and development and as a supporting tool to geothermal power production expected to start soon. Some country energy strategies, like The Strategy for use of RES of Slovak Republic, do not currently recommend any other incentive/s besides the feed-in tariffs and guarantees of origin, which apply solely to RES power generation (thus of being not applicable now – since no geothermal power has been generated so far, but there are some plans for the future).
Another system of RES deployment's incentives is represented by various types of certificates (guarantees of origin) – like green certificates, white certificates, among others. They may be applied both to RES power and RES heat generation. In only two from GEOCOM countries: Hungary, Italy these systems apply also to geothermal energy:

- *in Hungary* green certificates for RES/geothermal heat (but very few are generally used or accepted),

- *in Italy* white certificates for district heating (DH) and domestic warm water (DHW) production using geothermal heat and for ground sourced heat pumps (GSHP) with a high energy saving potential (not cumulative with other government incentives). White certificates are not cumulative with other public support measures; green certificates: for DHs connected to High Efficiency CHP; for electricity production in CHP coupled with DH. Thermal feed-in-tariff is only for small size RES heat production plants (< 1MW).

New feed-in-tariff system regulates incentives for electricity generation from RES (including geothermal) in new plants (in operation after 1/1/2013) and it includes additional incentives (and direct access to incentives) for power plants using advanced technologies (table 3).

Table 3. Italy: feed-in-tariff system for electricity generation from RES (including geothermal energy)

Base Feed-in-Tariff	
Power < 1MWe	135 €/MWhe
Power from 1 MWe to 20 MWe	99 €/MWhe
Power > 20 MWe*	85 €/MWhe
Additional award – incentives	
For the first 10 MWe each new area	30 €/MWhe
Total injection of geothermal fluids and zero emission plants	30 €/MWhe
High enthalpy plants removing 95% of H2S and Hg	15 €/MWhe
"Pilot Plants" with given features	Up to 200 €/MWhe (non-cumulative with above tariffs)

* Plants with P>20MWe: incentives are awarded through participation in lowest bid auction procedures. But according to trade associations, the lowest bid auction discipline is difficult to apply to geothermal sector because of the required capital intensive investments, the existence of an high mining risk and authorization procedures long lasting and complex.
Innovative plants may gain access to simplified procedure to benefit of these incentives.

As for geothermal district heating, except for possible regional incentives, most of financial support measures are for end-users, national financial support for investments (only 20% tax credit on investment) is limited and inadequate. Regional incentives change depending on the region: some region may support investments in new plants (through guarantee funds, co-financing, long term agreement with energy servicing companies (ESCOs), etc.), some other do not.

In Macedonia the Strategy for use of RES does not currently recommend any other incentive/s besides the feed-in tariffs and guarantees of origin, which apply solely to RES power generation. The geothermal sector does not benefit from this system since no geothermal electricity generation has taken place in the country so far (in the future – maybe some prospects for binary installations / CHP exist).

In Poland green certificates are introduced for RES electricity generation, but not for RES heat (therefore, geothermal heat does not take any advantage). Such measures are also not predicted in the project of new RES Law (*still in proceeding by the Parliament in February 2015*).

In Serbia, there are incentives available for renewable electricity production, including the obligation to purchase electricity from a privileged producer, prices at which the energy is purchased (i.e., feed-in tariffs) and the period of validity of the obligation to purchase electricity and download balancing responsibilities. These will apply also for the case of electricity generation using geothermal energy (so far no such installations have been operating)
Incentive measures stipulated in the Law on Energy are further defined by the Decree on Incentives for privileged energy, which in addition to a feed-in tariff prescribe the following incentives:

1. Incentive period of 12 years for all privileged power producers that were put into operation in less than 12 months before the signing of the contract on the purchase of the total amount of electricity produced with public supplier or incentive period of 12 years, minus the difference between the contract conclusion and the release commissioning for all other privileged power producers;
2. The right privileged producer who previously gained temporary status of privileged producers to sell to the public supplier the total amount of electricity produced during the Incentive Period following the encouraging price that is valid at the time of acquiring the temporary status of privileged producer;
3. The amount of electricity produced during the Incentive Period following feed-in tariff which was valid at the time of acquisition of the temporary status of privileged producer;
4. Download the balance responsibility and costs of balancing privileged producer during the period by stimulating public supplier;
5. Free monthly notification privileged producer and supplier of public production of electricity in the house privileged producer by a competent operator system during the Incentive Period;
6. The right privileged producer after the expiry of the period of stimulating the public supplier conclude a contract to purchase the total amount of electricity produced by market conditions in the regulated electricity market in Serbia.

Feed-in tariffs are guaranteed by the Government of Serbia energy entities with the status of privileged producer. Height of feed-in tariffs depends on the type of installed power plant for which the person has acquired the status of a privileged producer and is adjusted annually by the amount of inflation in the euro zone (in the case of natural gas indexation is made in accordance with a change in gas prices).

Starting from 01.01.2014. in Serbia the feed-in tariffs in the range 6,92-9,67 c€/kWh for geothermal power plants are prescribed by the Regulation on Incentives for privileged energy.

In Slovakia feed-in-tariff system is the main instrument to support RES electricity generation. This financial measure was established by the Act No. 309/2009 Coll. on promotion of RES in 2009. Responsibility for its implementation lies with the Ministry of Economy as well as the Regulatory Office for Network Industries and Slovak electricity transmission system. The Act and its amendments help with the market integration for RES. It sets a mandatory purchase of electricity produced from RES, until the specified fix output, for different types of RES (similar requirements are in some other GEOCOM countries). These provisions apply to geothermal energy (the prospects for binary schemes exist in some particular areas and localities and some power generation is expected soon).
Tariff level for geothermal electricity is as follows (Decree of the RONI No. 184/2012, 22 June 2012):

1. Plants in operation before 1.1.2010 and during the year 2010: 195,84 €/MWh x coefficient (depending on the year of construction),
2. Plants in operation from 1.1.2011 to 31.12.2011: 195,84 €/MWh,
3. Plants in operation after 1.1.2012: 190,51 €/MWh.

However, so far three GEOCOM countries (Macedonia, Poland, Romania) have been missing financial subsidies for geothermal energy generation (electricity, heat) like feed-in-tariffs or certificates of origin. Even if the relevant prospects are limited, these tools would serve also to enhance R&D works and activities on local scale.

Other financial measures available for investments

These are mostly in forms on loans and credits granted by banks. Geothermal investments and works eligible for financing are usually parts of wider programs dedicated to RES, energy efficiency, etc. They are available in four GEOCOM countries: Hungary, Macedonia, Poland, Romania.

Financial measures dedicated for drilling and operation of geothermal wells

Financial measures dedicated for drilling and operation of wells are perceived in growing number of European countries as the tools of special importance and specific for geothermal energy which, in fact, form an indispensable starting point for investments in this sector.
Regretfully, in prevailing number of the GEOCOM countries no specific financial measures dedicated for drilling of geothermal wells like subsidies for drillings and/or geological risk insurance funds (short-term, long-term) are available (specially that the drilling the wells is capital intensive phase and statistically from every 4 wells, 1 is unproductive). So far this measure has been available (to some extent) only in Hungary.

In Hungary geothermal drillings are to some extent subsidized by the Structural Funds. Recently, the experts urge the implementation of the German system of supporting geothermal wells where the amount of funding received per drilled meter is the function of the target depth and investors may receive a flat rate of 200€/kW for the built-in geothermal output capacity as a one-time subsidy.
Furthermore, Geological risk insurance funds (short, long term) are being considered (as given in more details e.g. in the IEE GEOFAR Project reports; www.geofar.eu) (table 1, 2).

One shall point out that lack of support for drilling the wells and/or risk insurance fund forms a serious constraint which significantly slows down or even hampers wider geothermal energy development (specially for space heating) – drilling new wells is the most expensive part of investment costs which impacts also many other financial aspects. Moreover – since existing financial measures are dedicated mostly for the above-surface parts of geothermal installations, one may really benefit from them if a well is existing – an indispensable "path" to transfer geothermal energy/fluid from its underground reservoir to the surface (and than to apply it for various purposes). Otherwise, many of financial measures formally/potentially available for geothermal as an element of RES will remain unused (this is e.g. a case of Poland – several local authorities and other investors can not afford to cover the drilling costs without public financial subsidies (low-rate loans and credits do not meet their financial abilities – even if included into state and EU financial plans by 2020) are not able to develop geothermal projects (specially for heating needs and district heating systems) and to benefit in many ways (environment, economic, social ones) from such energy source applications and accessibility of financial support oriented for the items other than drillings – a *sine qua non* element of any geothermal project.

General remarks on the financial measures and constraints for geothermal energy development in the GEOCOM countries

In general, the availability of various financial support measures (from national and EU-sources and programs) for geothermal uses' development in the GEOCOM countries is very moderate. In addition, in almost all cases, the existing ones were not tailored specially for geothermal energy but for the whole RES sector and geothermal can be among the beneficiaries if it meets their general provisions. This results also from the fact that geothermal is not prioritized in national energy and RES strategies of the Project countries.

As an positive exception one may indicate Italy – several tools operational there one can propose to replicate and transfer to other Project countries as best practice solutions. Relatively many tools (8 out of 12 analyzed) are available also in case of Hungary (although Hungarian partners indicate some important shortages). The worst situation is in Romania and Slovakia (only 2 types of measures are existing from among 12 concerned). Other three countries (Poland, Macedonia, Serbia) are characterized by an intermediate, but also not satisfactory situation (also in comparison with other RES) which would sufficiently facilitate geothermal energy uses' deployment.

One shall specially notice the lack of tools specific for deep geothermal, i.e. subsidies for geothermal drillings and/or Geological Risk Insurance Funds in the GEOCOM countries (with some exception of Hungary; table 2).
As discussed before, this barrier significantly slows down or even hampers wider geothermal energy development (specially for space heating). Here, the GEOCOM Partners shall transfer or follow good practice examples from some other EU-countries where introduction such tools significantly boosted geothermal development, like in France, Denmark, Germany or the Netherlands (www.geodh.eu).

Looking at the kind of "chain", i.e. starting from the investors of geothermal installation through its producers to final consumers, one may summarize financial measures existing / absent in the GEOCOM countries as follows (details are given in table 2):

- *In case of investors:*
In none of the GEOCOM countries flexible depreciation of geothermal investments or favorable tax treatment for third party financing are available. Investment, start-up subsidies (for surface infrastructure), other financial measures (from banks, private sector, other) exist in half (3 – 4) of analyzed countries, including Italy where several types of subsides are available (both for geothermal electricity and heat).
Relatively best situation is in case of subsidies for small and medium entrepreneurs (SMEs) what results from general state and EU policies towards supporting these economic group in general (and geothermal business in six GEOCOM states may benefit from it, too). Similar situation is in case of subsidies for new jobs' creation in RES sector (since geothermal is a part of it).
But first of all, investors in several GEOCOM states are missing tools specific for deep geothermal, like subsidies for drillings and/or geological risk insurance funds (which hampers new investments and limits possibility of making a real use of support for surface parts of investment);

- *In case of geothermal energy producers:*
Support systems as feed-in-tariffs (for electricity) has been introduced in only 3 countries so far: Italy, Hungary, Slovakia. In practice, it has been really operational in Italy only – where power generation from high-enthalpy resources has been ongoing for decades in Tuscany (in proximity of Montieri – GEOCOM pilot site). In two other listed countries this tool was introduced in recent years but has been not practically implemented so far (some geothermal power generation (low-enthalpy binary schemes) is expected to start in the forthcoming period). But one shall point out that FiT plays an important role to

- enhance the development and to attract potential investors.

In Italy, also thermal FiT is available – but only for small size RES heat production – this includes geothermal heat pumps (GSHP).

Green certificates (certificates of origin) are in use in three countries (Hungary, Macedonia, Poland) for RES /geothermal electricity generation while in Italy they are for RES heat for district heating connected to high-efficiency combined heat&power plants (CHP), white certificates are also in use. However, there are not any green certificates for geothermal /any other RES heat! Similar situation is in many other EU countries (regretfully) since RES heat is not number one in RES energy mix.

- *In case of consumers:*
Fiscal measures (in different forms) for various consumers (private, public, groups) to purchase geothermal equipment, i.e. heat pumps (as element of individual RES installations), and thermal retrofitting are accessible in three countries – Hungary, Italy, Poland. In some cases they are sporadic and cannot keep up with the demand. The most diversified measures are in case of Italy (they shall be considered for introduction in other GEOCOM countries as being the best in Europe).

4.3. Environmental, water protection, sustainability issues and constraints

Environmental constraints

For the group of main impacts that may result from geothermal water and energy exploitation, management and utilization (disposal) one may include reservoir pressure decrease; probability of pollution of fresh groundwater and waterways on surface during drilling operations; blow-outs; impact on surface water by spent geothermal water (if not injected back into aquifer); noise; air pollution emission by geothermal power plants.
Before enumerating these impacts one shall point out that the most negative of them do not occur or are significantly limited when spent geothermal fluid (i.e. after heat / energy extraction or used for other purposes is injected back into reservoir.

- Reservoir pressure decrease:

This effect usually occurs in prevailing number of exploited geothermal reservoirs. In many cases the level of its effect is acceptable and does not influence a lot a long-term exploitation.
However, in some cases, specially when no injection is applied, it can appear as more significant and have more serious impact on exploitation conditions and maintenance of long-term sustainable production from geothermal aquifer. This impact is referred from Hungary mostly - specially when in prevailing number of cases there is no injection of spent geothermal water back to the aquifer while discharging water from the wells has been ongoing for decades. Significant pressure decrease occurs mainly in porous sandstone reservoirs. In some fields that have been exploited for more than seventy years (!) the piezometric reservoir pressure decreased almost by 70 meters (the Hajdúszoboszló field). The long-term geothermal operation also resulted in up to 40 m drawdown in the Szentes field. Despite this significant pressure drop, geothermal water in mentioned localities are still being exploited (of course, pumping out these water requires more electricity for running the pumps).
All experts point out that most problems of the geothermal operations can be avoided by means of injection. However, till now despite the widespread use of geothermal energy resources, only a small amount of spent geothermal water is injected back (see also report D5.1 from GEOCOM works; www.geothermalcommunities.eu).

- Probability of pollution of fresh groundwater and waterways on surface during drilling operations

To tap geothermal aquifer, drilling shall go through shallower aquifers situated above which often contain freshwater. Therefore geothermal drilling operations have to be done with special care to avoid any, even potential hazard to these freshwater reservoirs. During drilling situations downhole drilling fluids may create the potential threat to environment, similar to well completion and stimulation operations using acid. Hence, proper drilling technology, casing program during drilling and other works are compulsory to protect freshwater and drinking water aquifers and to avoid any, even potential threat. In this respect one shall note that no pollution of ground freshwater induced by geothermal drilling operation were reported in recent years from the GEOCOM countries.

- Blow-outs:

The greatest environmental hazard during drilling operation could be a well blow out, sometimes accompanied by thermal effects and noise. Such incidents happened occasionally in the past but almost each was publicized (so as undue role was often ascribed to such cases).
E.g. in Hungary the most serious blow out of a geothermal well was in Fábiánsebestyén in 1985: the brine flowed to the small creek Kórógy which lost all kinds of life. The noise level during the outburst reached 125 dB. One shall add that such incidents are very rare since proper protection of wellheads (blow-out preventers), proper conducting of drilling and other works in wells. Health and safety, other regulations, as well as EIA are very demanding in these respects in all GEOCOM countries.

- Impact of spent geothermal water into surface water (if not injected back into aquifer)

When spent geothermal fluid is not injected back into the aquifer but discharged into surface waters it may impact surface water quality by changing its acidity (pH), adding chemicals (originally not present in surface water or in lower quantity) some of which may contaminate this water, and increasing surface water temperatures. To avoid this, appropriate regulations and provisions are operational in all countries. The process of disposal of spent geothermal water into surface water in in prevailing number of cases is a subject of careful monitoring. Some examples follow:

In Hungary, mineralization of geothermal waters is comparable to that of seawater but some have higher values. The water of the Upper Pannonian aquifer contains mainly sodium or calcium carbonate, in the Lower Pannonian formations mainly sodium chloride. The environmental impacts of geothermal waters disposed into surface waters can be serious. In many cases there is no injection at all; used geothermal fluids are spent into surface creeks or rivers, and disposing into ponds is also very common. Some waters contain toxic material (e.g. arsenic) and pathogenic organisms (bacteria) which, if released into natural waterways, could harm their wildlife.

In Italy spent geothermal fluids (without gas components) can be injected into their host reservoir, or disposed in other manner (i.e. in surface water bodies), after being adequately treated in order to minimize their environmental impact. The environmental and hydrogeological impact of disposed water must be always constantly monitored.

In Poland mineralization of geothermal waters discharged to surface water bodies usually does not exceed a few g/L. Discharge of waters is conditioned by obtaining a special water permit. A surface water body is considered to be a living environment of specific species of fish (including carp and salmonids). In this context, conditions in the water mixing zone, especially water temperature should comply with the EU Directive 78/653/EWG (18 July 1978 - on environmental quality standards for certain substances and heat transfer to specific stocked freshwaters) and national laws of the Water Law and the relevant regulations. Similar conditions for EU members also impose: 1) Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life and 2) Water Framework Directive of the European Parliament and of the Council of 23 October 2000 establishing a framework for community action in the field of water policy. The environmental and hydrogeological impact of disposed water always have to be constantly monitored.

In Slovakia pollution standard, i.e. values after mixing discharged water with surface water, is laid down in the Government decision No. 269/2010. It also includes the limits for water temperature:
- temperature after mixing spent geothermal water with surface one should not exceed 26°C,
- for recipients intended for fish farming, these temperature should not exceed 28°C.

- Noise

Noise is rather a short term impact and occurs mostly during the drilling works (usually lasting not more than several weeks). The noise is limited by setting special silencing screens around the drilling area, and at the drill rig. Moreover, modern rigs currently generate little noise, usually are located relatively far from inhabited areas. The maximum level of noise generated by drilling works and then by operation activities is regulated by relevant laws and provisions in all the GEOCOM countries.

- Air pollution emission by geothermal power plants:

These impact refers to geothermal steam exploitation (Tuscany, Italy) and partly to geothermal water exploitation which may be accompanied by releasing of gases (H_2S, CO_2, CO, NH_3, CH_4) and other chemical particles (Hg, As, Sb, Se, Si) into the ambient. In Italy - the steam parameters covered by the national legislation represent only partially the current emission framework (H_2S, Hg, As), also characterized by unregulated pollutants (e.g. Sb, Se, NH_3, CH_4, and CO) and for which emission limits are not established. Environmental monitoring of these substances only depends on possible regional level limits. Additionally, national legislation is referred to hourly average (calculated on monthly basis), implying a continuous monitoring of emissions, which is still technically impossible to implement for geothermal power plants. Moreover Hg and As national limits are only referred to dissolved salts in drift (1% of total), since an official and reliable technique for this sampling design does not yet exist. To avoid the release prevailing part of above-listed chemicals into the environment, special technology has been applied in Larderello-Monte Amiata region (close to the GEOCOM pilot-site Montieri) where power generation takes place based on geothermal steam.

Injection of spent geothermal fluids vs. financial context of sustainability and environmental costs of their disposal into surface water streams

As was already pointed out, the injection of spent geothermal fluids (i.e. after extraction part of their heat for practical purposes) back to the reservoir (aquifer) is the best and optimal way to maintain long-term sustainable exploitation and reservoir behavior and to avoid any (even potential) negative impacts to the environment. However, in the GEOCOM countries the injection is generally not obligatory acc. to the legislation, but some other regulations and provisions give additional reasons to apply it (mostly environmental aspects, EIA considerations). It is or can be recommended on the cases by case basis, the entrepreneurs decide on the mode of exploitation (closed, open systems) taking also into account the financial aspects first off all: drilling of not only one production well but at least one injection well usually doubles investment costs therefore it is the main constraint for injection. The cases below give an insight into the injection practice in particular countries.

In Hungary injection is not obligatory acc. to existing law regulations. In prevailing number of cases there is no injection of spent geothermal water back to the aquifer while the discharging water from the wells has been ongoing for decades and the amount of water produced in this manner is really great (Hungary is among the leaders in geothermal uses in Europe, specially in bathing / recreation but the heating sector is also important and growing branch). To illustrate sustainability issues in a financial context table 4 gives some factors that impact method of geothermal waters exploitation (without, with injection) and related investment/running costs on unit costs of geothermal energy.

Table 4. Hungary: selected factors showing the impact of method of geothermal waters exploitation (without, with injection) and related investment / running costs on unit costs of geothermal energy

Locality of geothermal project	Used geothermal heat energy (GJ)/exploited amount of water (m^3)	Investment cost €/GJ /y	Running expenses € /GJ/y	Used geothermal heat energy (GJ)/ 1 M € investment costs (€)	Remarks
Törökszentmiklós	0,104	96,6	4,27	0,23	No injection. Using waste water heat of a public bath
Szentlőrinc	0,037	156,6	2,9	0,07	No injection. Significantly high public heat service fees
Dombóvár (planned)	0,201	53,4	2,2	0,20	No injection. High water base risk
Csongrád	0,207	48,3	3,4	0,23	No injection. Using waste water heat of a public bath
Gyopáros	0,188	106,2	3,9	0,11	Injection (2 wells)
Makó	0,248	44,9	2,5	0,25	Iinjection (2 wells)

Injection increases investment costs (capex). This is quite evident from the costs of drilling and completing an injection well: with average drilling costs of around 440 EUR / meter and the costs of equipment needed, capex related to including injection wells into a geothermal project add up to around 0.8 Mio EUR in the Hungarian projects studied for the purpose of this report. Although it is rather hard, if not impossible to speak of "average type" projects in case of geothermal investment, based on the investment costs of the four projects completed in Southern Hungary in last 5 years: capex related to injection made 20% of full project's costs. It is easy to come to the conclusion that any project with injection will be 20% more expensive than its counterpart without such measure.
However, operation costs related to injection are, more often than not, smaller than those occurring from other methods of spent geothermal water disposal. This is due to high environmental taxes and fines imposed on operators of systems with surface discharge.
Operation costs of a geothermal well are as follows:
Electricity costs: 0.025 €/m^3
Filtering: 0.024 € /m^3
Maintenance of surface equipment: 0.003 €/m^3
Maintenance of subsurface equipment: 0.05 €/m^3
These add up to around 0.1 €/m^3 of geothermal water.

In case of systems without injection, taxes and fines add up to around 0.2 EUR / m^3 costs - in excess to the environmental burden caused by surface discharge of spent geothermal water (including salt and heat contamination on the surface as well as a loss of pressure and declining water levels below).

In Italy in order to prevent the degradation of environmental quality of surface and ground water, the disposal of exhausted geothermal fluids without being properly treated (with expensive techniques) is not allowed since 1976. Hence the injection of spent geothermal fluids (previously

separated from the gaseous fraction) was successfully tested, as it also resulted in an improvement of the pressure and production of geothermal reservoirs, making geothermal energy exploitation more sustainable for long-term uses. Indeed the charging time of a geothermal reservoir use to be rather slow, since the average rock permeability is approximately 10^{-14} m^2.
However, high silicates contents and physical-chemical characteristics of geothermal fluids may cause fouling of injection wells. This could be solved by reducing silica contents in spent geothermal fluids before their injection.

Spent geothermal fluids of water-dominated reservoirs may also be used for drinking purposes, after being adequately treated (through distillation), in order to comply with current provisions concerning drinking waters.

Spent geothermal fluids (without the gaseous component) can be injected into their originating geothermal reservoir, or disposed in other manner (i.e. in surface water bodies), after being adequately treated in order to minimize their environmental impact. The environmental and hydrogeological impact of disposal must be always constantly monitored.

Concerning injection wells, the current practice of using old production wells for the injection is not always the best and the planning of injection during the geothermal exploitation initial phase is increasingly considered as the best solution.

Injection of geothermal fluids is incentivised at national level – in case of total injection of geothermal fluids and zero emission pilot power plants the incentive is 30 € /MWhe (see incentives at subchapter 4.2 on Financial issues) and for a sustainable use of the resource, it is the only method currently applied to dispose spent geothermal fluids from geothermal power plants. Moreover the injection of geothermal fluids prevents subsidence phenomena (specially in cases of high-enthalpy steam/ reservoirs). In case of direct applications, the injection of spent geothermal fluids is obligatory in Tuscany but not in other regions of Italy and there re no incentives for that.
Regional authorities may decide to enforce mining lease procedure for the reuse of spent geothermal fluids or gases from geothermal plants.

Injection is a way to dispose spent geothermal fluids and it is not properly mandatory. It is preferred as compared to other disposal ways (and actually it is the only way used to dispose spent geothermal fluids), since it can ensure a long term exploitation and use of geothermal reservoir, it is incentivised (see above) and it is an alternative to expensive treatment processes.

In Macedonia, Romania and Serbia (similar like in Hungary) there is no obligation to inject spent geothermal water back to the reservoir. It results in fact that no attention is paid to the long-term sustainability of the geothermal resource.

Also *in Poland* injection of spent geothermal water is not obligatory and generally not required as a rule by the legislation (geological and mining law, water law) but it is considered and recommended on case by case basis. In particular cases the operators have to apply this technology, specially if water has high TDS content, since other environmental and water law regulations and requirements do not allow to dispose high TDS water into surface water streams). Also the operators (specially in case of geothermal heating plants) apply or tend to introduce injection as a tool to maintain long term sustainable production from the geothermal reservoir – necessary as a basis for safe and stable development and management. However, in such situation the investment costs are significantly higher and injection wells are sometimes designed and drilled not at the initial stage of the project but later (when the installation is already bringing some incomes).

In Serbia, spent geothermal fluids management is defined by The Law on Water. It defines that construction and design and construction shall be such that: 1) enables discharge to the stream after the use of energy; 2) does not reduce the current volume or to preclude the use of water to supply the population and other users; 3) does not diminish the level of protection from the harmful effects of water; 4) does not deteriorate the conditions of sanitary protection; 5) ensures their multipurposed use. However, it does not define the obligation on geothermal fluids' injection.
Within the GEOCOM Project a detailed assessment of the state of geothermal energy in Serbia, especially in terms of the legislative framework and executive powers was carried out. In this country the incentives for the use of geothermal energy do not appear to be specific, but only within the framework of incentives established by the Energy Law or Regulation on Incentives for privileged electricity producers. If we take into account known expert opinion that the hydrothermal resources in Serbia are suited for direct application, not for generation of electric energy, the question is how such a general measure of incentives for electricity production from alternative sources can be effective in increasing the uses of geothermal energy. It is clear that the appropriate measures and incentives of the state should allow the construction of facilities for the rational, economically, environmentally and socially justifiable uses of geothermal energy. For this purpose it is necessary to specify subsidies usage of this type of energy, for the design and construction of geothermal systems, in order to motivate domestic and especially foreign investors, who have a solid project and financial resources.

In Slovakia there is also no obligation on geothermal fluids' injection. When geothermal systems were designed and constructed no attention was paid on long-term sustainability of their resource. Spent waters are discharged into surface waters. Based on several analyzes one may say that injection without financial support (e.g. from state budget, EU Structural Funds, etc.) is unprofitable.
In this respect, Galanta pilot site forms a good example of introducing sustainable method of geothermal resources' exploitation and use: in this locality, thanks to the GEOCOM Project, research works on geothermal injection well were conducted. This work shall contribute to improve the methods of exploitation, maintain stable features of geothermal reservoir and ensure stable parameters of produced water – basis for local district heating system. However, also in case of Galanta economic considerations on drilling of injection well for geothermal heating system have proven that its realization would be unprofitable without financial support (co-financing).

Environmental impact assessment – a formal requirement for geothermal energy development projects

Environmental impact assessment (EIA) for geothermal energy development projects are required *in all GEOCOM* states and their provisions are rather similar. EIA serve to evaluate any environmental constraints and potential negative impacts related to injection/lack of injection, spent geothermal water release, water pollution, air pollution, etc. and the methods to limit and reduce these impacts.

In Italy geothermal projects related to capacities above 1 MW (and with wells deeper than 400 m) are subordinated to EIA screening (procedure duration 150-330 days) and possibly to EIA (procedure duration 90 days). EIA screening has to be delivered to the environmental authority when applying for the exploration and exploitation permits to the regional authority (or other delegated authorities). EIA screening is mandatory also for surface installations, but specific limits and rules change region by region.

In Macedonia, as for any other foreseen investment (plant, system, building) environmental permit precedes with the elaboration of the assessment of the influences to the environment (EIA) (according to the Law on Environment).

In Poland research or exploration of mineral deposits (including geothermal water) performed by drilling (including deeper than 1000 m), in cases of:

- the water intake protection zones,
- protective areas of inland water reservoirs,
- areas covered by the forms of nature protection (the act of 16 April on the protection of nature applies), requires EIA screening and possibly to EIA.

Each geothermal well's drilling at depths of more than 5000 m (what is not a practical case still) and *geothermal water extraction from boreholes* (of each depths) *is obligatory preceded by EIA* (*t*he provisions in respect to EIA and several other items are generally oriented for oil&gas exploration, hence the range of depths to which they refer to).
EIA screening has to be delivered to the regional environmental authority when applying for the exploration and exploitation permits/licenses (Regional Director of Environmental Protection). EIA screening is mandatory also for surface installations.
In case of wells shallower than 100 m (drilled as borehole heat exchangers for heat pumps) only notification to the country office is required.

In Serbia, EIA is also required for geothermal energy uses projects, in accordance with the Law on Environmental Protection. However, there are no special stipulations for geothermal projects implemented recently (regardless of the effective Law on Environmental Protection), which foresees surface geothermal installations.

Land concession, geothermal exploration, exploitation, drilling permits and licenses

In all the GEOCOM countries land concessions (as well as licensing systems for geothermal drillings) are legal mandatory basis for the activities related to exploration, exploitation and uses (development) of geothermal water and energy resources. They differ in details among particular countries. Some insight into the situation in selected states is given below.

In Hungary, as regards geothermal energy, „closed areas" are the parts of the Earth crust below 2.5 km from the surface. To drill the wells deeper than 2.5 km, trough a concession contract entered into with domestic or foreign legal entities or natural persons the relevant minister may concede the prospection, exploration and exploitation of geothermal energy in closed areas with definite period of time. The right of prospection shall grant an exclusive right for the mining entrepreneur in the area of prospection. The investor shall submit a technological operation plan for the prospection of mineral raw material or to submit a technological operation plan. The planned period of prospection may not be longer than 4 years. This period may be extended no more than two occasions, by half of the original period of prospection per occasion. Within the period of 1 year of the completion of the prospection the mining entrepreneur may initiate the designation of geothermal protective zone. If the holder of concession fails to commence the exploitation or the geothermal energy use he shall pay a compensation, fixed in the contract. If he fails to meet his obligation to pay compensation, the concession shall cease to exists.

In Italy national and local related geothermal resources belong to "mines" category. According to art. 826 of the Civil Code they are classified as goods property of the Italian State (national related resources) and of the regions (local related resources), available with a concession issued by a delegated public. Resources for *small local uses* are considered as underground resources (belonging to groundwater category), being the property of Italian State (as before).
Geothermal projects of capacities less than 2 MWt, with wells shallower than 400 m are called "*small local uses*" and require a "simplified" procedure known as "*Unique Authorization*" and authorities in charge for the administrative functions are Italian Regions or delegated authorities (e.g. provinces or

municipalities). Other geothermal projects require an *exploration permit* and an *exploitation permit*, both issued and managed by Italian Regions or delegated authorities.
More details follow below:
Exploration permit: applicant must demonstrate adequate technical and financial capability (e.g. bank guarantee) and a work plan, as well as EIA (if required). Maximum surface of each permit is 300 km^2 (1000 km^2 at regional level and 5000 km^2 at national level), time required to approve an application should last 240 days but may be longer (mostly for environmental assessment) and it costs up to 325 €/km^2/year;
Exploitation permit: it is a mining lease lasting 30 years and it allows to perform all activities for the exploitation of geothermal resources on a specific area. It requires a work plan and a bank guarantee or insurance for environmental recovery, as well as EIA (in particular cases). Maximum annual lease for exploitation is 650 €/km^2. Moreover companies have to pay compensations for each KWh produced (0,13 cent€/KWh to municipalities and 0,195 cent€/KWh to regions). Regions (e.g. Tuscany) may apply additional fees through voluntary agreements for the exploitation of geothermal resources in power plants, reinvesting the revenues for the development of geothermal areas.

Total time needed to obtain all permits (EIA included) is usually 38 months (long).
In cases of pilot experimentation plants and for offshore geothermal resources, the authority in charge for issuing permits is the Ministry of economic development in agreement with the Ministry of Environment.

Compulsory purchase procedure is sometimes necessary for surface works. In this regard bureaucratic processes may slow down geothermal projects.

In addition to the above one shall add that in case of low enthalpy resources uses, ministerial procedural guidelines on technical management aspects are needed, as well as a monitoring system for the uses of the resource, since dynamic nature of local alterations is not considered.

In Macedonia, if the land where the geothermal activities are foreseen is in private property, it is not necessary to obtain concession for the land use. The procedure involves obtaining permit for the intended activities which should be in accordance to the land category (industrial, building, agricultural or else), if not than procedure for makeover of the land category must be initiated. The land concessions are granted if the land is in the property of the state i.e. municipality according to the Law on Concessions and Public Private Partnership, Law on Building Land (Official Gazette of RM, no.17/2011 and 53/2011), and the Building program of the Municipality.

Main laws and regulations that regulate the right of exploration of geothermal site are:

- Law on Mineral Resources (Official Gazette of Republic of Macedonia No.136/12, 25/13),
- Law on Concessions and Public Private Partnership (Official Gazette of Republic of Macedonia No.6/12) regulates the general rules of the procedure for granting of concessions and Public Private Partnerships,
- Decision on commencing with the procedure for granting concessions for detailed geological surveys of mineral resources.

In case of permits or licenses' systems for various kinds of geothermal drillings (exploration, exploitation ones) in Macedonia, relevant permits and concessions are granted by the government and several ministries are involved in various ways in the procedures. The system is rather formalized and multi-staged (as described in details in Annex 2).

In Poland, permit for drilling of geothermal wells and license for exploitation of geothermal waters are issued by the Marshal of the Voivodeship (regional administration level). Exploration permit – requires a decision approving the geological works project (validity period depends on the complexity of the project and work schedule). EIA is required when drilling is located in: the water intake protection zones, protection areas of inland water reservoirs, the areas covered by forms of nature protection. EIA screening is also needed for drilling deeper than 5000 m. Consent for the extraction of geothermal waters is issued in the form of a license for a period of up to 50 years. It specifies: mine-field boundary and mining area boundary as an area where operator can extract geothermal water, so the range of the cone of depression shouldn't go beyond these boundaries. Obtaining a license for water exploitation requires also the EIA decision. Application for a building permit shall include: permit drilling and water discharge (issued by Regional Head Office For Water Management) and other construction permit (issued by the Building Authority in the given area/ district/ province). *One shall specially point out these favorable conditions for issuing the permits and licenses for geothermal drillings put into force by new geological and mining law in 2012.* It simplified some procedures by, among others, introducing a single system of licensing (for exploitation wells) and transfer it to the competences of regional administration (before the licenses were obligatory both for exploration and exploitation wells and issued by the minister of environment). Other provisions facilitating geothermally-oriented activities include:

- exemption from royalties for geothermal water exploitation,
- exemption from fees for the geological information used for project purposes,
- reduction of fees for the use of geological information in order to exploit geothermal water (up to 1% of its value to 31/12/2020, then 5%),
- cancellation of licenses for exploration and prospecting of geothermal water – just geological works project to be approved by the regional administration (no need to prove the funds to operate, no license fee, no contract for mining operation /only the stamp duty for a decision/),
- shortening the exploitation license procedures by a significant reduction of the duties of cooperation with other bodies while issuing the decision on concession.

Polish system presents a good practice of optimizing procedures related to drilling geothermal wells.

In Serbia, if the land on which geothermal energy exploration and use activities have been foreseen is a private property, there is no need to acquire concession for the use of the land. The procedure implies the acquisition of permit for the planned activities, which should be compliant with the category of the land (industrial, building, agricultural or other).
Land concessions are granted in cases when the land is a state, or municipal property in line with the Law on Concessions and Public-Private Partnerships and the Law on Building Land.

*In Slovakia, t*he approval / permitting process is under the authority of the Ministry of the Environment of Slovak Republic (MoEnv SR):

1. Exploration/ exploitation permit – includes obtaining concession/ permit for use of the area of interest; (permission is given for 3 years, then it is possible to apply for an extension). Report on the use must be submitted to the MoEnv SR each year (information on the ongoing exploration and/or drilling).
2. EIA is required - the assessor is appointed by the MoEnv SR, but the applicant has to pay for assessment (this also includes a public meeting in the respective municipality; the intention of the project must be presented to the public).
3. Relevant river basin determines the conditions for the discharge of geothermal water into the recipient (temperature of discharged water and its mineralization) in accordance with the Water Act and Government regulation/ (see above, Environmental constraints).
4. Approval of project realization by all institutions that are affected by construction: distribution system operators (gas/ electricity/ water), land owners, the competent national authorities (Regional Office for Environment, etc.) and to determine the conditions for the project realization.
5. Application for a building permit shall include: permit drilling and water discharge (issued by the competent Regional Office for Environment) and other construction permit (issued by the Building Authority in the affected area/ municipality).

6. Procedure for selection of supplier (one for all activities/ construction works) or suppliers (to supply technology, drilling, other construction works, etc.)
7. Conclusion of the contract.
8. After completion of drilling, the Final report is submitted for approval to the MoEnv SR (must be signed by the minister) - here are intended conditions of operation and after two years is revalued
9. Inspection
10. Commissioning/ putting in operation (permit is issued by the Regional Office for Environment and Building Authority), here are intended operating conditions

Water rights

In all the GEOCOM states the activities related to exploration, exploitation and uses (development) of geothermal water and energy resources fall into the provisions of water rights (following country and EU- regulations). In details they may vary from country to country.

*In Hungary t*he water rights licensing procedure is the part of the Act LVII of 1995 on Water Management. There are four different types of license:
- conceptual water rights license (eligibility for planning),
- water rights license for installation (eligibility for constructing the facilities),
- water rights license for operation (eligibility for operating the facilities),- water rights license for continuance (eligibility for further operating the facilities).

The Government Decree No. 220/2004. (VII. 21.) Korm. on the protection of surface water quality sets up the *water resource fee* for geothermal water uses (as in case of other types of water).
This is a contribution to be paid to the central budget on all water uses. In case of surface waters, for example in a water plant or regarding water used for irrigation, and in case of underground waters, e.g. drinking water, bathing water, etc., the basis for the contribution is the water volume actually used as determined by measurement and the water fee (HUF/m^3) which is identical in each water application, but because of the different multiplication factors, significant differences arise among the various utilization approaches. From the aspect of harnessing geothermal water, there are only two important subsurface water categories: naturally one is geothermal water and the other is qualified medicinal water, because most of the latter are geothermal waters as well (T>=30 °C). The water fee depends on the type of water use and water reserves, and it is modified by the multiplier ‘g’ subject to the water reserves management situation in the relevant area. The rates of the multiplier ‘g’ are the following: Energetic utilization falls into the ‘economic’ ‘other’ category and hence has the highest multiplier.
Consequently, the KHVM (Ministry of Environmental and Water Conservation Affairs) decree 43/1999 (XII. 26)KHVM expressly gives preference to medication and considers energetic use as the least desirable. No water reserves contribution is to be paid, if after energetic use spent geothermal water is returned to the underground aquifer (and this is absolutely logical, because in this case no use (consumption) of the water reserves is involved). The rate of water fee is determined by the State Budget Act, and hence it changes from year to year. And it has indeed doubtlessly and dramatically increased in the last two years. On figures 1 and 2 (when 2000 and 2001 are regarded as the reference years, respectively) it is shown how the water fee, natural gas and electricity prices have grown along with the annual inflation. It can be seen that the rise in water charges has slightly exceeded the inflation up to 2000, and then sharply climbed afterwards. Expressed in figures, this means that in two years the water fee grew by 79% nominally. Vis-à-vis energy supplied through conduits, the situation is even worse, as a result of which it can be stated that the competitiveness of harnessing geothermal energy has deteriorated as against the major competitor natural gas.

And the problem is not with the geological properties of Hungary in terms of geothermal energy. There are two reasons why these vast reserves remained relatively unexploited to date. One of them is that the geothermal waters which are available at a reasonable cost (up to 2500 m in depth) suit primarily direct heat applications and they do not support the concept of power generation (due to their relatively low temperatures). In addition to that there is a certain level of uncertainty involved in each new geothermal project, namely whether the drilling will manage to find the geothermal water or not. If this objective fails a significant portion of the overall project budget had been spent in vain. For this reason the lack of financial support towards these initiatives are the main hurdle Hungary will have to come over in the upcoming years, by drafting a reasonable risk insurance system to protect those at some degree who wants to venture off in this realm.

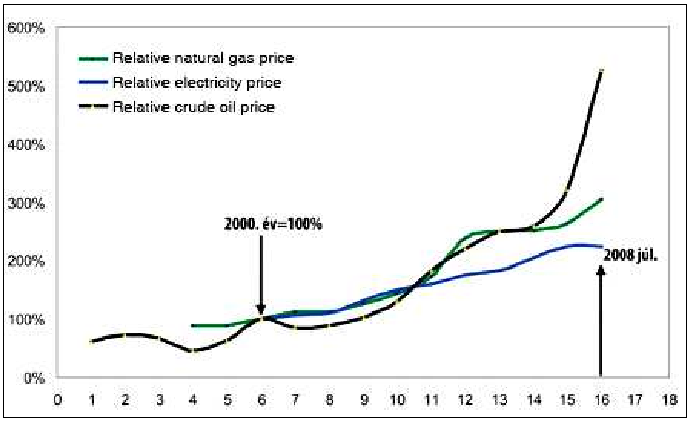


Figure 1. Hungary: relative evolution of energy prices compared to the base year of 2000

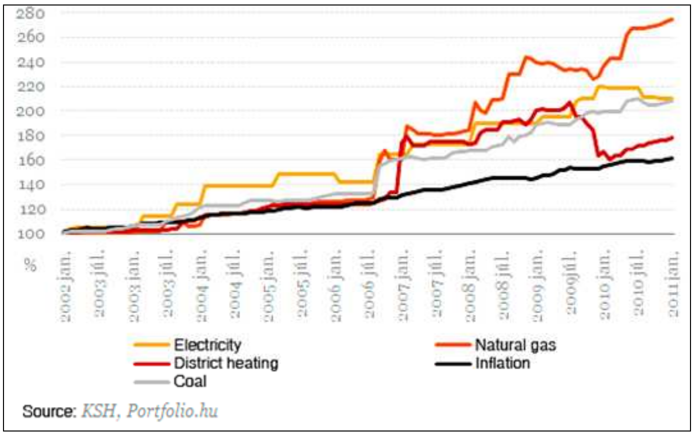


Figure 2. Hungary: evolution of inflation and energy prices

In Macedonia the procedure for granting a right (concession) to explore or exploit geothermal resources is organized in the form of a tender procedure and is governed by the Act on Concessions and PPPs and Decision on commencing with the procedure for granting concessions for detailed geological surveys of mineral resources or Decision on commencing with the procedure for granting concessions for exploitation of mineral resources. The concession types, and the terms and conditions are regulated by the Law on Mineral Resources and the Law on Waters. For the use of water in geothermal exploitation, concession for water use must be obtained. The Law on Water provides that the concession for water use shall be implemented in the form of a public tender or as a formal request. The tender procedure can be in the form of a public call initiated with a formal proposal from the Minister of Economy. The proposal for granting the concession must emanate from the Ministry of Economy and the decision to commence the procedure and the decision to grant the concession (for exploration or exploitation) must be passed by the Government of Macedonia. In addition prior to conclusion of the Concession Agreement, the permit for water use must be also obtained by the Ministry of Environment.

In Poland the permission of the Water Law in geothermal exploitation apply to discharging spent geothermal waters into surface waters. The permit is required for the discharge of used water to surface watercourse. Such water has to meet the relevant requirements in respect to temperature and physical-chemical composition. These requirements are introduced by the Regulation of the Minister of the Environment (18 November 2014) for the placing sewage into the water or ground; and for substances particularly harmful to aquatic environment (Journal of Laws 2014, item 1800).
Each member of the European Union according to the Water Framework Directive was obliged to achieve the good status of water quality and ecological status in separate surface water bodies. Therefore, the quality of water discharged to surface receivers cannot affect the conditions of water management in the catchment areas defined by the Water Management Plans. These plans are reviewed at the national level every six years, in accordance with the criteria laid down in Art. 4 WFD (*Environmental Objectives of WFD).* Good status of water quality should be achieved by 2015. In appropriate cases, where the interest of socio-economic development takes precedence, temporary derogations to separate sections of the river are allowed. In these case good condition should be achieved in the shortest possible time, in subsequent planning periods (2021, 2027) or as soon as possible after this year.

In Serbia, water rights are granted by the Ministry of Agriculture, Forestry and Water Management, the competent authority of the Autonomous province of Vojvodina or the city of Belgrade depending on the place where the building will be located.
Prior to the issuing of water conditions (which are elements of the location permit, and are necessary for the preparation of project documentation-main project) it is necessary to obtain the opinion of the Republican organization in charge of hydro-meteorological affairs (the Republic Hydro-meteorological Service, RHMS) and the opinion of the public water management company (JVP "Srbijavode" – the territory of the Republic of Serbia except for the Autonomous Province of Vojvodina, or JVP "Waters of Vojvodina" – the territory of the Autonomous Province of Vojvodina).
With the request for issuing the water rights shall be submitted basic information about the location, purpose and size of the object, previous studies and general design, with the impact of the structure on the water regime. In addition, a request for the issuing of water conditions it is necessary to submit: 1) a copy of the plan (showing the location of the object) – issued by the competent Real Estate Cadastre; 2) land certificates (for the cadastral lot on which the building is constructed) issued by the competent municipal court or other competent authority; 3) certificate of resolved property-rights relations: evidence of ownership on the land, approval of the public water management company, if it comes to building a structure of public interest on the water land; 4) land use plan, which is issued by the municipal planning department.

Economic viability and cost-effectiveness of geothermal projects in relation to avoidance /reduction of CO_2 emissions (carbon footprint reduction)

As a general remark to information presented in this subchapter one shall note that it is rather difficult to compare directly information and data collected by particular GEOCOM Partners. This is because they refer to various cases, approaches, various elements included into investment costs, and various fossil fuels taken as reference bases (natural gas, coal, etc.) – as one may judge taking into account e.g. wide range and different orders of values' magnitudes of some unit costs of CO_2 reduction thanks to geothermal uses in individual countries. To obtain more comprehensive picture, one should also confront the unit costs of CO2 /CO2 eq reduction thanks to geothermal source with reductions thanks to other RES. Therefore, the analyses of information gathered in course of the

GEOCOM works led to conclusions that it would be of purpose to elaborate a common objective methodology for evaluation the cost-effectiveness of geothermal projects in relation to avoidance /reduction of CO_2 emissions. Some aspects of such potential methodology could be applied following the approach of Polish Partners and authors of regional and global prognoses (given further in this subchapter).

What can be stated without any doubts and proves the advantages of geothermal in comparison with other RES is that, despite higher investment costs, it guarantees a continuous production through the year, with a capacity factor near to 1. As a matter of fact 10 MWe of geothermal installed electric capacity are equivalent to the production of 40-50 wind power MWe (!).

In Italy, according to an assessment document on GHG emission reduction (by National Agency for new technologies, energy and sustainable economic development (ENEA, 2010), geothermal is the second most affordable technology for the reduction of CO2 emissions, after refuse-derived biogas. These assumptions are made considering that CO2 emissions from geothermal power plants are natural and conventionally not included in GHG emission quotas allocated to EU countries, hence geothermal power plants contribute to achieve GHG emission reduction 2020 EU objectives. However, contrary to most of geothermal fields around the world, Italian geothermal fields have high content of carbonate rocks, which in 2010 resulted in a real average emission from geothermal power plants equal to 360 g $CO2/kWh_e$. As for geothermal heat pumps: air-water pumps have lower costs than geothermal ones, but they imply higher environmental impact and lower productivity.

In Hungary the cost effectiveness of geothermal projects in relation to avoidance/reduction of CO2 emissions is well exemplified in table 5 by cases of four geothermal space heating projects, including the Morahalom heating system – the GEOCOM pilot-site. In every case given in this table natural gas as a source of heating was partly or totally replaced by geothermal energy as a result of the investment. Drilling production and injection wells are included in the investment costs (except for in the case of Csongrad). Figure 3 shows location of geothermal projects listed in table 5 with operating injection wells.

Table 5. Hungary: cost effectiveness of geothermal projects in relation to reduction of CO_2 emissions. Cases of four geothermal space heating projects, including Morahalom – GEOCOM pilot-site

Location of geothermal space heating project	Mórahalom 1 injection well	Szeged University 4 injection wells	Csongrád no injection	Makó 2 injection wells
Produced and used geothermal heat energy (GJ/y)	18.000	86.000	55.931	67.000
Earth gas ransoming (m^3/y)	482.000	2.900.000	920.000	2.192.000
CO_2 reduction (t/y)	1.400	5.900	1.663	3.847
Investment costs (netto Mio €)	1.75	6.4	1.3	3.1
Running expenses (netto €/y)	137.000	226.000	195.000	173.000
Inner rate of return (%)	10,5	9,8	7,14	4,16
Time of return (y)	10,5	11,5	9,7	14
Unit costs of CO_2 reduction (netto €/Mg)	57	49	36	37

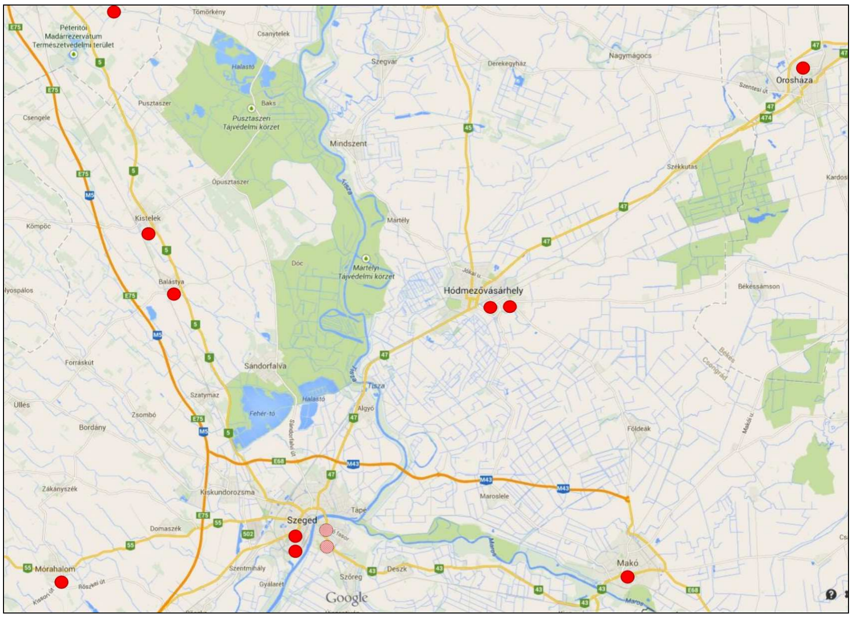


Figure 3. Hungary: location of geothermal projects with operating injection wells in the South Great Plain (marked are Morahalom, Mako, Szeged given in table 5)

In Macedonia the existing geothermal resources are of low-temperature nature, therefore they are used mainly in balneotherapy and heating of greenhouses and some buildings. The exploitation systems are old (more than 30–40 years) – when designed and realized no attention was paid to the CO2 emissions avoidance. Even today, this data is not regularly calculated and taken into consideration.

In Poland: before referring to CO2 / CO2 eq reduction issues, some introduction to geothermal heat costs and other important expenditures and costs' elements is given.

a. Prices of heat (supplied by district heating systems) from various energy carriers:

An average net price of heat from district heating grid for the end user (including energy price and its distribution) may be estimated as follows (based on Pająk & Bujakowski, 2013):

- based on coal: 10–17 €/GJ, mean value 13.5 €/GJ,
- based on natural gas: 15.5–21 €/GJ, mean value 18.3 €/GJ,
- based on fuel oil: 21–28.3 €/GJ, mean value 24.7 €/GJ,
- based on geothermal: 12.2–20.2 €/GJ, mean value 16.2 €/GJ.

These prices were estimated on the basis of tariffs applicable in 2013. It might be assumed that they included all costs components (investment costs of acquiring energy and its distribution, applicable taxes, etc.). Moreover, also electricity is sometimes used for heating (especially in old buildings in the centers of cities). In such cases, the price for the end user (net value), can be estimated as 33 €/GJ.

b. Costs of reducing emissions – case of replacing coal (dominating in Poland) by geothermal energy and methodology of their evaluation:

<u>When comparing the heat prices one may note that only the energy from coal is cheaper than energy from geothermal in Poland.</u> One can therefore assume that only in terms of comparing geothermal to coal as an energy carrier ecological considerations may generate additional costs. In other cases, the use of geothermal energy is a matter of economics. Of course, environmental effect is obtained in parallel. With some generalizations and assumptions, the costs of reducing emissions of main pollutants can be estimated as follows (assuming replacement of energy from coal by geothermal):

- total dust: 3–18 €/kg,
- CO_2: 55–341 €/Mg,
- SO_2: 8–50 €/kg,
- NO_X: 93–570 €/kg.

The above numbers take into account investments costs, technically possible energy consumption by the users, technical viability of geothermal system components equal to 22 years (period resulted from accounting regulations). Moreover, these costs refer to pure $CO2_2$ emissions, not CO2 eq (as commonly given in many reports and literature (including also quoted below). Inclusion in the above costs the equivalent CO2 emissions would cause lowering of costs in relation to the above values.

The methodology for evaluating the above mentioned value applied for the purpose of the GEOCOM works was as follows (Pająk & Bujakowski, 2013):
On the basis on authors' knowledge and experience, one can assume that in Polish conditions geothermal water stream possible to obtain from a well is in range from 50 to 200 m^3/h.
Assuming cooling of geothermal water in heating installation by approx. 30 K, the capacity of a single well from geothermal doublet could be estimated at 1.8 to 7.2 MW_{th}. In country's climatic conditions, and taking into account standard facilities, an average amount of thermal energy produced from installed unit capacity for heating purposes equal approx. 7 $GJ/kW_{installed\ capacity}$ (while average installed capacity use factor is approx. 0.22, which gives ca. 7 GJ/y (1 kW*0.22*8760 h/y = 1.9 MWh/y ≈ 7 GJ/y). Therefore, the amount of thermal energy obtained from a single geothermal production well can be estimated for 12.6– 50.4 TJ/y.
The presented methodology assumed that geothermal source is the only one used to meet the needs of the recipient. When geothermal energy would work with the peak boiler (hybrid system), the amount of thermal energy produced from the unit installed capacity could be much higher. Unfortunately, accurate estimate are possible only for specific solutions. Since the main purpose of presented calculations was to estimate the emission reduction costs, therefore calculated costs can be considered as the maximum ones.
This methodology was the same as the one used by e.g. Wesselink&Deng (2009) and McKinsey&Company (2009) to evaluate specific /unit abatement costs of CO2 eq (GHG) prognosed for Europe and globally. According to Wesselink&Deng (2009), the specific abatement cost of a measure (€/Mg CO2 eq) is calculated from the sum of annualized investment costs and annual operation and maintenance (O & M) costs minus the annual financial savings from the measure's energy costs, divided by mean annual greenhouse gas emissions savings of the measure. Both the CO2 savings and the costs are relative to a reference situation:

$$\text{Specific costs} = \frac{\text{annualized capital costs} + \text{annual O \& M} - \text{annual energy cost savings}}{\text{annual CO2 emissions savings}}$$

c. Costs of drilling geothermal wells – dominant component impacting costs of emission reductions:

The dominant component of the geothermal investments related to energy generation are wells (boreholes) – for this reason, their valuation is characterised in some more details:
Costs of geothermal well completion were estimated for standard works (i.e.: drilling, casing, cementing, filtering and well head installation, well logging, well testing, elaboration of the documentation). Well's equipment such as fiberglass casing and other well operations and works were not included due to substantial increase of the costs. The experience gained during tender works for specific well projects has shown that the offer prices can be different by 100%.
Figure 4 illustrates drilling costs of standard geothermal wells. These costs should be treated as indicative (based on Barbacki et al., 2013) and were calculated based on global drilling costs data (Chad et al., 2006). They were also updated by the 18% inflation rate in period 2014–2015 (total – 1.6%/y). The exchange rate was as 3.2 PLN=1 USD. In Polish conditions, the depths of geothermal

well that allow to obtain water temperature sufficient to apply in conventional heating system, are ca. 2 800 m. Figure 1 shows that the cost of drilling new well of 2.800 m in depth is approx. 20 Mio PLN (4.8 Mio €). Cost of drilling the wells' doublet (aimed to obtain mentioned parameters) and main elements of surface installation is estimated for approx. 10 Mio €. If it would be possible to use already existing well (after its reconstruction) the price of the doublet could drop down to approx. 27 Mio PLN/6.5 Mio € (20 Mio PLN – new well and 7 Mio PLN – 'old' reconstructed well).

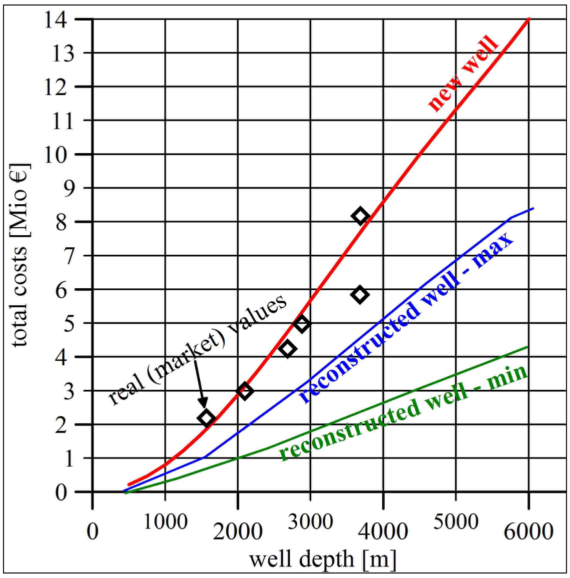


Figure 4. Poland: projected capital expenditures related to drilling and reconstruction of geothermal wells. Rectangles: real drilling costs (based on Barbacki et al., 2013, modified)

d. Reductions of main emissions and their estimated unit costs:

Assuming that operating costs of geothermal installation consist mainly of depreciation of fixed assets, it gives the annual operating costs at level of 296–455 K €/y (depreciation period of 22 years, acc. to accounting provisions in Poland). Lower costs are associated with doublet of one newly drilled well and one reconstructed; higher costs – with two newly drilled wells).

In case when geothermal installation reduces the cheapest heat source currently available, i.e. coal, the environmental effect should be referred to the avoidance/reduction of emissions generated from burning this fuel. For coal, emission factors are as follows: 2.06 kg/GJ – total dust, 106 kg/GJ – CO_2, 0.7 kg/GJ – SO_2, 0.06 kg/GJ – NO_X (values taken from literature on emission from various energy carriers; Pająk, 2007).

Hence, geothermal heating installation replacing coal can eliminate/reduce annual emissions of:

- total dust: 26–104 Mg/y,
- CO_2: 1336–5344 Mg/y,
- SO_2: 9–36 Mg/y,
- NO_X: 0.8–3.2 Mg/y.

Finally, referring the annual exploitation costs of geothermal wells' intake to the avoided emission, one obtains the unit costs of emissions' reduction at the levels:

- total dust: 4–18 €/kg (two new wells' doublet), 3–11 €/kg (doublet of one new and one reconstructed well);
- CO_2: 85–341 €/Mg (two new wells' doublet), 55–222 €/Mg (doublet of one new and one reconstructed well);

- SO_2: 13–50 €/kg (two new wells' doublet), 8–33 €/kg (doublet of one new and one reconstructed well);
- NO_X: 142–570 €/kg (two new wells' doublet), 93–370 €/kg (doublet of one new and one reconstructed well).

It should be noted that the way (methodology) to determine the unit cost indicators of the emission reduction includes also all of the analyzed pollutions. These costs should not be added together – if one incurs expenditures for the reduction of one of them, the rest will be eliminated as costless.

e. Reductions of main emissions and their estimated unit costs – other GEOCOM countries:

Following the methodology applied for Polish case, an attempt was made to estimate unit costs of CO_2 emission reduction in case of Macedonia and Hungary (based on data provided by the GEOCOM Partners and given in table 5).
In Macedonia, the costs of drilling (and basic equipment) a geothermal well are at the level of 700–800 €/m (meter) (for wells up to 800 m deep) – these values comply with the values presented at figure 4. In this country, from one unit of installed capacity (1 kW) one gains 9 GJ/y, so the respective unit factor is 9 GJ/y/ 1 kW.
Fuel oil is a reference fuel to which the pollution emissions shall be referred to in case of thermal energy production. For fuel oil pollutant emission factors are (Pająk, 2007):
- total dust: 0.053 kg/GJ,
- CO_2: 48.95 kg/GJ,
- SO_2: 0.113 kg/GJ,
- NO_X: 0.148 kg/GJ.

For Macedonian geothermal parameters, the expenditures for the realization of one doublet of wells can be estimated at approx. 2 Mio euro in case of drilling the doublet of two new wells (2 x 1 Mio €) and approx. 1.5 Mio € in case of doublet of one newly drilled well and one reconstructed.

Assuming geothermal water flow rate at the level of 50-200 m^3/hr and of 75°C wellhead temperature (acc. to Popowska-Vasilevska et al., 2010), the thermal capacity of geothermal intake would be at the level of 1.5 – 5.8 MW and yearly energy production at level of 13.5 – 52.2 TJ/yr.

On the basis of these assumptions cost of reducing emissions can be estimated as follows:
- total dust: 33–126 €/kg (doublet of two new wells), 25–95 €/kg (doublet of one new and one reconstructed well);
- CO_2: 35–136 €/Mg (doublet of two new wells), 27–103 €/Mg (doublet of one new and one reconstructed well);
- SO_2: 15–59 €/kg (doublet of two new wells), 12–45 €/kg (doublet of one new and one reconstructed well);
- NO_X: 12–45 €/kg (doublet of two new wells), 9–34 €/kg (doublet of one new and one reconstructed well).

The result of estimations for Poland and Macedonia are given in table 6 (in addition, a rough estimation for Hungary is added, based on data included in table 5).

In Serbia annual GHG emissions from the energy sector are estimated at 52.97 Mt of CO_2 equivalent, with 2/3 of CO_2 emissions resulting from the 1990 production of electricity. There is still no information available from the official data on emissions of greenhouse gases, and communication in connection with the UN Framework Convention on Climate Change is an ongoing preparation. Preliminary analyzes lead to estimates that the overall potential reduction in carbon emissions in Serbia as part of the 20–25 Mt of CO_2 equivalent per year.

Table 6. Unit costs of reducing CO_2 emissions by implementation of investments aimed at the production of geothermal heat. Results of estimations described in the text, based on input data provided by some GEOCOM Partners, data from 2010-2014

Country	CO_2 reduction costs, €/Mg	Comments
Hungary	36 – 57	Estimated on data given in table 5. Reference fuel: natural gas.
Macedonia	27 – 136	Lower value – installation which would work on the basis of geothermal doublet: new well + reconstructed well, water flow rate at level of 200 m^3/h. Higher value – for doublet with two wells drilled as new and water flow rate at level 50 m^3/hr. Wellhead temperature approx. 75°C. Reference fuel (reduced): fuel oil.
Poland	55 – 341	Assumptions as to types of geothermal wells' doublet as above. Reference fuel (reduced): hard coal.

In Slovakia, the impact of geothermal projects on environment manifests itself mainly in reduction of emissions from burning solid fuels and natural gas which was the main objective of these projects.
The first company in Slovakia using geothermal energy for heating by district heating supply was Galantaterm s.r.o. established in 1995. The most expressive results were achieved after starting up the operation of Galantaterm in 1997. From that time the quantity of emissions from gas is influenced by various objective factors and by factors of production in consequence of which the quantity of monitored emissions of CO_2, NOx, SO_2 and dust moderately increases or decreases.
Emissions derived from two sources, from geothermal water and natural gas:

- in 2011 CO_2 emission from geothermal water of wells FGG-2 and FGG-3 amounted to 8.35 t/y,
- total of CO_2 emissions from gas in the year 2011 was 388.48 t/y,
- total of CO_2 emissions from geothermal water and from gas was 396.83 t/y,

The main source of CO_2 emissions in Galantaterm is natural gas. But the emission of CO_2 would be much higher if geothermal water was not used. The main benefit of this project is the considerable reduction of emissions which is on average above 4000–5000 t/y.

The unit CO2 reduction emission costs in the GEOCOM countries – an attempt for comparison with other European countries and the world

Formulas for calculating the unit CO2 eq reduction costs:

An attempt was made to compare estimated unit CO2 reduction costs related to replacement of traditional fuels by geothermal in heating sector obtained for some GEOCOM countries (table 6) and on a wider European background.
However, despite literature screening and searching available national and EU- data bases and statistics, the authors of this Report did not find information on exact particular/average unit CO2 reduction costs resulted from replacing fossil fuels by geothermal and/or other renewables in heating and power sectors in current years of the GEOCOM Project realisation (say 2010-2014). It seems that no such kind of data have been collected and published, and no general evaluation methodology (presented in some prognostic reports for 2020, 2030 and beyond, i.e. by Wesselink&Deng (2009), McKinsey&Company (2009a)) has been introduced into common practise and usage so far. This situation is striking specially that many attention has been paid on the CO2 emission trading prices while their unit costs have not been the subjects of equal importance so far (!). Therefore, the authors of this Report found it difficult to compare them on wider bases of particular countries and Europe as a whole. One had to limit himself to some general statements, i.e.

where these costs were the lowest (Hungary) and where were the highest (Poland). The visible differences might result, among others, from big differences in drilling costs (but not only).

The formula to calculate unit (specific) CO2 eq reduction costs applied by Wesselink&Deng (2009) in the prognosis for EU27 in 2030 was as flows (its main assumptions were already given on page 34):

$$\text{Specific costs} = \frac{\text{annualized capital costs} + \text{annual O \& M} - \text{annual energy cost savings}}{\text{annual CO2 emissions savings}}$$

Equivalent formula was applied by McKinsey&Company for global prognosis and for Poland (McKinsey&Company, 2009a, 2009b):

$$\text{Abatement cost} = \frac{[\text{Full cost of CO2e efficient alternative}] - [\text{Full cost of reference solution}]}{[\text{CO2e emissions from reference solution}] - [\text{CO2e emissions from alternative}]}$$

The results of estimations when applying the given formula should be the same.
(Unit costs of CO2 eq reduction evaluations are shown on figures 5 -7 further in the text).

Application of formulas to the GEOCOM cases:
In case when one dealt with concrete cases of three GEOCOM countries, the above-described methodology took into account the following assumptions:
a) that the recipient's use of energy sources currently provide coverage of their heat demand. Accordingly, the position [Full cost of reference solution] equals 0. It is greater than zero only when one takes into account the investment for new heat source;
b)that the position [CO2 eq emission from alternative] = [CO2e emission from geothermal] and that geothermal energy generates no emissions.

Based on the above assumptions, the formula for evaluating the specific (unit) costs of reducing CO2 eq emissions becomes:

$$\text{Abatement cost} = \frac{[\text{Full cost of CO2e efficient alternative}]}{[\text{CO2e emissions from reference solution}]} =$$

$$= \frac{[\text{annualized capital costs}] + [\text{annual O \& M}] - [\text{annual energy cost savings}]}{[\text{annual CO2 emissions savings}]}$$

if [annual energy cost savings]=0 → $\text{Abatement cost} = \frac{[\text{annualized capital costs}] + [\text{annual O \& M}]}{[\text{annual CO2 emissions savings}]}$

Thus, considering simplifying assumptions, the calculation formula of unit costs of reducing CO2 eq emissions applied by McKinsey&Company (2009a, 2009b) is consistent with the formula by Wesselink&Deng (2009). The latter formula was used for the purposes of this GEOCOM Report to estimate the discussed costs in cases of some geothermal heating installations in Hungary, Macedonia and Poland.

Results and discussion of comparison:

As already noticed, several global, EU- and national prognoses were elaborated to predict, among other, the potential for CO_2 eq (GHG) emissions reduction/ abatement and expected related unit costs (€/Mg CO_2 eq) in longer time horizons of 2020, 2030 and beyond (e.g. McKinsey&Company (2009a) for global scale, Wesselink&Deng (2009) for the European Union (for 650 technologies), McKinsey&Company (2009b) for Poland).

In case of Poland – one of the GEOCOM country, geothermal was not considered in cited report by McKinsey&Company (2009b) as a separate renewable energy source. However, one may place it somewhere in the renewable groups represented by biogas, wind, dedicated biomass (figure 5). The prognosed unit reduction costs in this group would belong to interval 30-35 €/Mg CO_2 in 2030 (while for data from 2014 and before these costs were evaluated for 55-341 €/Mg; table 6).

For the European Union, the relevant prognosis for 2030 unit CO_2 eq abatement costs for geothermal shall be the lowest in the RES group (!)– in range of – 20 € /Mg CO_2 eq (Wesselink&Deng, 2009) – what means how much one may save compared with the costs of a reference when abating 1 Mg of greenhouse gases (figure 6). When looking at concrete figures evaluated for the purpose of this Report for available cases of Hungary and Macedonia (based on data from 2014 and before) they are in the range of 36-136 €/1 Mg (table 6; figure 6, 7), so already now they are relatively low and allow for positive prognoses for the future that geothermal can be among the most efficient and low-costs technologies for CO_2 eq /GHG abatement (in Macedonia being among the cheapest renewable options in the country; Dedinec et al., 2012).

Furthermore – it is visible that in some cases the current unit costs of CO_2 reduction related to replacement fossils by geothermal shall be lowered in the forthcoming years to be comparable and competitive with effects obtained using different technologies and energies. In many cases (e.g. Poland) this shall be realistic thanks to, among others, technological development and optimization (lowering) of drilling and operation costs. Figures 6 and 7 illustrate comparison of several data that characterize current unit CO_2 reduction costs if geothermal is replacing fossils (using the methodology applied by Polish GEOCOM Partner – as described before) on a background of McKinsey diagram for EU27 for 2030 (using the methodology of unit costs' evaluation by Wesselink&Deng (2009). One shall point out that this gives only a general view which opens the way to further more systematic and in-depth research and considerations in particular GEOCOM countries and Europe as a whole.

Referring to other way of CO_2/GHG emission reduction: one needs to note that many reports and research outcomes have indicated that not only optimal selection of energy type and its management but also the energy efficiency in buildings, retrofitting of residential buildings, thermal insulation are among the cheapest options of unit CO_2 reduction costs of significant potential in various branches (figures 6, 7) in all countries. To give an example: within a 25 year perspective, not only power generation (electricity, heat) and manufacturing industry will offer significant opportunities for reducing emissions but also energy efficiency measures – since almost 25% of such reduction may result from applying these measures which – in addition – carry no net costs so in effect they are free (Conlon; http://www.esbi.ie/ news/pdf/White-Paper-CO2-Emission-Reduction.pdf (thus they will allow for saving the costs comparing with the reference basis; see also figures 5– 7).

These facts confirm the rightness of formulation the title, scope and objectives of the GEOCOM Project and its pilot investment works, specially that it combines high-efficient and low-costs' measures to reduce the CO_2/GHG emissions as the measures to increase the rational energy use: geothermal energy for heating, thermal retrofitting of buildings, optimal hybrid energy systems.

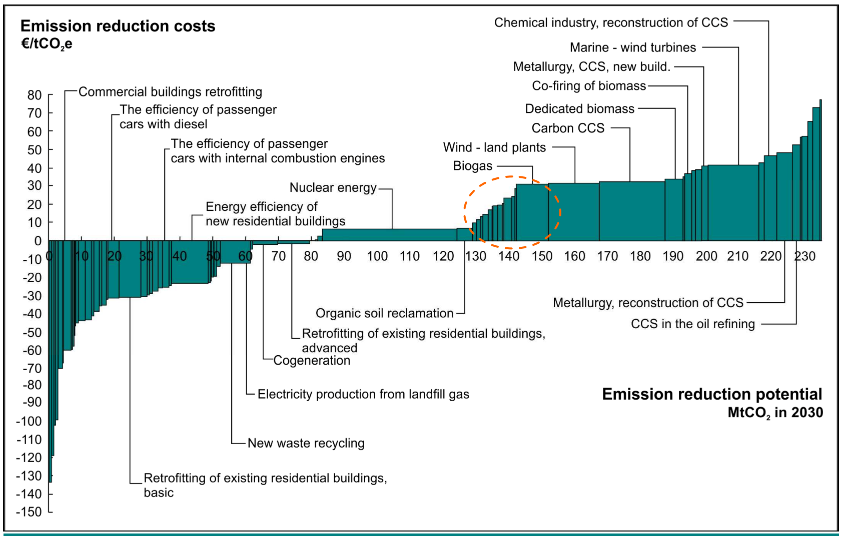


Figure 5. Poland: GHG abatement cost curve 2030. Only the most significant abatement opportunities were named. Average unit CO2 eq reduction cost of all technologies: 10 €/Mg CO2 eq Source: McKinsey&Company, 2009b.
(Geothermal energy may be approximately placed in the group of biogas and wind; see the text).

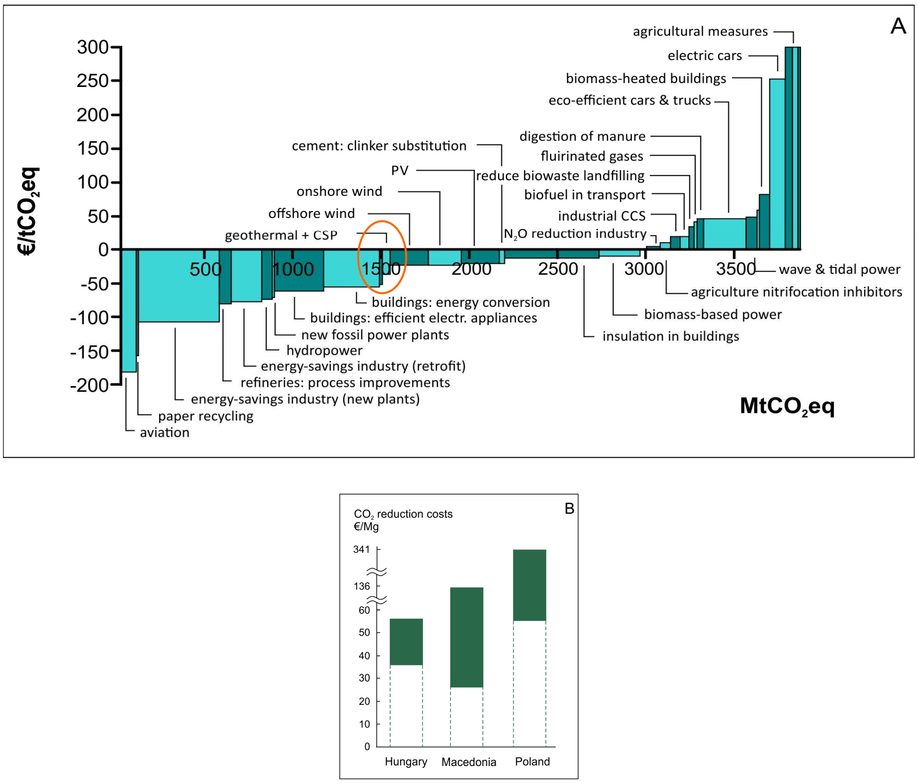


Figure 6. EU27: cost-curve scenario for 2030 cumulative abatement of CO2 eq emissions and unit reduction costs for various technologies (A). Source: Wesselink&Deng, 2009 (geothermal energy is shown in orange ellipse among various technologies) and Current unit CO2 reduction costs connected with replacing fossil fuels by geothermal in heating systems in 2010-2014 evaluated for some GEOCOM countries (B)

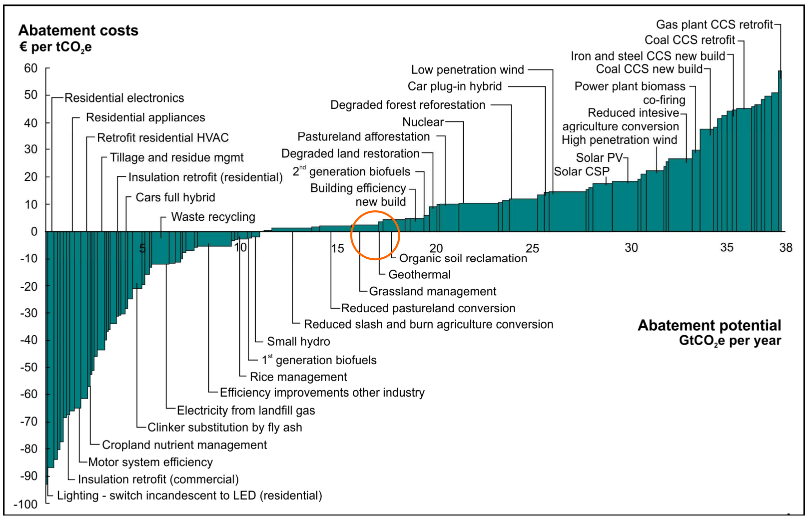


Figure 7. Global CO2 eq abatement cost curve beyond business-as-usual – 2030.
Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO2e if each. Source: McKinsey&Company, 2009a.
(Geothermal energy is shown among various technologies).

General remarks on environmental, water protection, sustainability issues and constraints in the GEOCOM countries

In general – as results from the review of situation in particular GEOCOM countries, there are almost no negative impacts related with a wide spectrum and various stages of geothermal energy uses' projects and activities. Slightly more complex is the situation with injection of spent geothermal waters / fluids. To large extent this is thanks to the very nature / specificity of resources and adequate preparation, conducting and management of projects, maintaining many high standards and regulations (that everywhere are high and demanding the more that are generally parts of the provisions for typical mining and oil&gas activities). Sometimes they are even too detailed and do not take into account the specificities of geothermal enough.

In the group of items presented in subchapter 4.3, main attention is focused on issues and problems related to injection, especially if there is a formal obligation to such type of utilization of spent geothermal waters in existing national legislations. With the exception of Italy, such a requirement is not included in them. In particular countries and cases, however, the injection is recommended or required by the licensing authority and included as one of the conditions for permits or licenses for exploitation and management of geothermal water / energy (e.g. in Poland).

Injection is conducted mostly by geothermal heating plants, where are large water flow rates, high TDS. Many operators are aware that this is indispensable condition which assures sustainable, long-term efficient exploitation. However, in many other cases injection is not applied (and are no fees or penalties for non-injection); such method would imply the need to incur significant expenditures for drilling injection well (especially in the absence of financial subsidies for geothermal boreholes and lack of geological risk insurance fund).

Additional – transboundary issues – are related to the situation when the injection or the lack of it concerns common geothermal aquifers located and managed in the areas of several countries (e.g. the Pannonian Basin in Hungary, Serbia, Romania and some other states; the Podhale Basin in

Slovakia and Poland): the approach to injection may be different, and national rules are not harmonised. The former of the listed cases formed subject of the GEOCOM studies and reports: „Injection to sandstone reservoirs technology showcase" (2013) and „Transboundary utilisation model" (2012). Both reports are available at http://www.geothermalcommunities.eu/downloads (access 30.01.2015).

Wider implementation of injection of spent geothermal waters (or at least their prevailing part) belong to the group of factors (targets) essential for sustainable geothermal uses development, reservoir and surface protection, as well as for economics of the projects. However, this the most correct method requires proper financial support and measures (some is provided in Italy – 'incentivising" injection). This need was is pointed out by e.g. the Partners from Slovakia: so far there is no obligation to inject spent geothermal fluids. In course of GEOCOM works for Galanta pilot site, economic considerations on drilling the injection wells indicated that it would be unprofitable without financial support (co-financing) available for local operator.
Injection offers also – as indicated by Italian Partners – an alternative for expensive geothermal waters' treatment processes.

After all, it should be emphasized that the injection is the best method of disposal of spent geothermal fluids. It would be thus important to find a way to convince decision-makers that support for such method (wells) should be a part of the overarching national policy of sustainable economic development, rational management of natural resources and their protection. On the other hand - the high cost of drilling are sometimes unjustified.

Higher capex costs in case of drilling two wells (including injection one) imply also higher costs of CO2 emissions reduction and other pollutants (an insight into the issues is given earlier in this section), although this is not so evident case of Hungary (as results from the information given in table 6). For instance in Poland, the unit costs of CO2 reduction were estimated at 85–341 €/Mg (including drilling two wells (production and injection) into capex). Without injection well they would be ca. 50% lower (42–170 €/Mg) and in case of one new and one reconstructed well 30–60–% lower.

In all GEOCOM countries the environmental impact assessment reports (EIA) are required. It is generally correct, since it serves the sustainable management and protection of geothermal reservoir and external environment. However, the procedures and the time of their preparation and then agreeing with competent authorities and public consultations is sometimes too long (. Italian case), especially from the point of view of investors.

Another issues to concern are permits and licenses for economic activities related to exploration, exploitation and management of geothermal energy resources. The procedures are still generally too complex and too long, and most of all – licenses are issued at the national levels. So far, only in Poland (since 2012) and partly in Italy (for low-enthalpy resources) the licenses and permits are issued at regional levels, what is optimal and friendly for the investors (solutions in force in these states may serve as good practices which could be followed in other GEOCOM countries).

In reference to economic viability and cost-effectiveness of geothermal projects in relation to avoidance /reduction of CO_2 emissions one shall state that it was difficult to compare directly the set of collected information, data collected by particular Partners, and results of analyses done in frame of the GEOCOM. Only some general considerations and comparisons were made. This was because they refer to various cases, approaches, various elements included into investment costs, and various fossil fuels taken as reference bases (natural gas, coal, etc.). Moreover than in case of CO2 eqavoidance/reduction in heating sector no reference unit costs have been available/evaluated at country and EU levels so far. Therefore, the analyses led to conclusions that it would be of purpose to

elaborate a common objective methodology for evaluation the cost-effectiveness of geothermal projects in this respect. Some aspects of such potential methodology could be applied following the approach presented by the Polish Partners.
This is an issue which shall be considered soon, specially that, according to Italian experience, geothermal is the second most affordable technology for the reduction of CO_2 emissions, after refuse-derived biogas.

4.4. Best practices of financial measures, environmentally-related regulations and solutions suggested to transfer among the GEOCOM countries

Comparison of collected information, data and analyses on "Overview of market drivers, Fiscal measures and subsidies" indicates, among others, some existing essential factors, and constraints (economic, environmental, technological) that control the geothermal energy development and related rational use of energy in particular Project countries. They were summarized in subchapters 4.2 and 4.3. Moreover – several of these factors and constraints will influence the discussed development also in the future (as indicated by the outcomes of structural cross-impact analysis).
Fiscal and financial measures and shortages were collected and presented in a form of General Matrix (table 2) in previous chapters.

In this section, several proper measures and solutions in force in some of the GEOCOM countries – which can be treated as best practices – are proposed and recommended to be transferred or adopted in other countries where they have been missing so far (2010–2014). They present solutions specific for geothermal energy projects (while more general ones referring to wider sectors of economic activities are not treated here). They are marked by green in table 2 (where more detailed description is given).

One shall point out that these recommendations do not present a theoretical or wishful thinking list, or tend to favor geothermal projects in the group of various traditional and renewable energy sources but reflect a real need (must) to place geothermal on a common playing ground with other sources (often much stronger promoted and lobbied).

Recommended best practices

Fiscal measures for consumers to purchase geothermal equipment, systems, energy:

- Subsidies for thermal retrofitting of buildings and increasing energy efficiency (as in Hungary, Poland), purchasing and installing heat pumps (small capacities),
- Lower VAT-10% (instead of regular 21%) to connect to a DH network and buy and install GSHP,
- Contribution to DH network connection (20,658 €/kWt, reduction on income tax of natural persons of 36 %),
- Fiscal credits on heat sold by RES DH network (0,0258 €/kWh and 10% VAT),
- Contribution to ground-sourced heat pumps, GSHP (reduction on income tax of natural persons of 50% of total costs).

The above solutions are in force in Italy (for thermal retrofitting in Hungary, Poland, Italy).

Investment subsidies for geothermal projects*:

Geothermal heat:

- Tax credit: 20% of investment costs in geothermal or biomass DHs,
- Incentive for DHs' end-users – to connect to main pipeline,
- Kyoto Fund: also finances shallow geothermal installations (GSHPs?) of capacity < 1 MWth,
- Other possible regional measures – to support investments (from the EU- structural, regional, and national funds),
- National Guarantee Fund for new district heating systems, DHs *(yet to be implemented).*

Electricity:

- Some cost reimbursement of implementation for final users

*Both are Italian cases

Financial subsidies:

- Subsidies for above-surface infrastructure /regional, EU-funds/ specially for heating infrastructure /some percentage of total costs) (Poland),

- Subsidies for heat and hot water preparation through low CO_2 emission and RES uses; Heat and hot water preparation and electricity generation through RES use for natural persons (Slovakia).

- Feed-in-Tariffs (FiT):
  - thermal FiT (for small size RES heat production only (e.g. GSHP), it lasts 2 yrs (if P$\leq$35 kWth) or 5 yrs (if P>35 and $\leq$1 MWth) and covers up to 10% of predicted costs) – as in Italy,
  FiT for geothermal electricity production (Italy, Slovakia)

- Green Certificates:
  - for district heating systems (DHs) connected to High Efficiency CHP;
  - for electricity production in CHP coupled with DH
- White Certificates:
  - for DH and DHW production using GT heat and for GSHP with a high energy saving potential (not cumulative with other government incentives) (in Italy)

Other financial measures available for investments (banks, private sector, other forms):

- Loans with lower interest rate for geothermal drillings and subsurface parts available at some banks, and for: surface infrastructure, energy efficiency measures and RES (Poland)

Best practices of environmentally-related regulations and solutions:

- Adequate permit and licensing systems and procedures (Italy, Poland),
- Regulations related to injection (Italy, Poland),
- Incentivise injection of spent geothermal fluids (Italy),
- Examples of efficient practical use of part of spent geothermal fluids before /instead of injection (Italy, Hungary, Poland),
- Reconstruction of wells re-use of post-hydrocarbons wells and their adoption for geothermal exploitation purposes (to decrease capex and several other costs) (Hungary, Poland),

- Shortening formal and administration procedures and transferring them into regional/local administration levels (Poland).

Recommended best practices from other European countries:

In addition, one shall suggest to consider some good practices from other European countries (not existing so far in the Project countries). These are two measures of paramount importance:

- Establishing Geological Risk Guarantee Fund for geothermal drillings (short-term, long-term). Such essential measure has been not existing in any GEOCOM country so far. It facilitates geothermal energy project development and results in initiating many successful projects as proved by the cases of France, Germany, Denmark, the Netherlands (www.geodh.eu),

- Introducing (maintaining) public subsidies for geothermal drillings (specially first wells), in particular if dedicated for energetic purposes.

4.5. Factors impacting geothermal uses development and promotion with an emphasis on rational energy use – research using foresight approach

In case of the GEOCOM Project task WP6.3, to investigate how and which will be factors impacting geothermal energy uses development, costs, promotion, understanding of RUE measures in the future (forthcoming 10–20 years) some elements of foresight methods survey were applied.
The main objective of such approach was to identify, or at least to gain some idea, on potential factors (i.e. set of events and trends), their interactions and roles for given future development (treated as a system). It was expected that several factors (and their groups) that would determine the evolution of the system in assumed timeframe would be defined, including the key factors of essential importance for future development.

Before discussing the reported studies done as part of the GEOCOM activities, a general introduction to the foresight technique is presented, as well as to one of methods applied during the studies and interpretation of results, i.e. structural cross-impact analysis (carried out with the help of MicMac software). Descriptions are given mainly following the information by Czaplicka-Kolarz [ed] et al. (2007), Pyka & Czaplicka-Kolarz [eds] et al. (2001), Wójcicki & Ładyżyński [eds] et al. (2008) (and literature there), as well as other sources cited in the text.

An interesting still growing literature over foresight, concerning both its theoretical basis and particular application examples is available in papers and e-publications. The European Foresight S&T Knowledge Sharing Platform and European Foresight Website, for instance, belong to the latter.

Foresight methodology – generals

In brief, Foresight is a methodology used for the future prediction analyses. But in fact the method is useful not only for predicting and making prognoses. Foresight supports the participants (“actors”, “experts”) to actively shape the future, being a non-deterministic, participatory and multidisciplinary approach. It can be envisaged as a triangle combining "Thinking the Future", "Debating the Future" and "Shaping the Future" (JRC EC 2014) (figure 8).

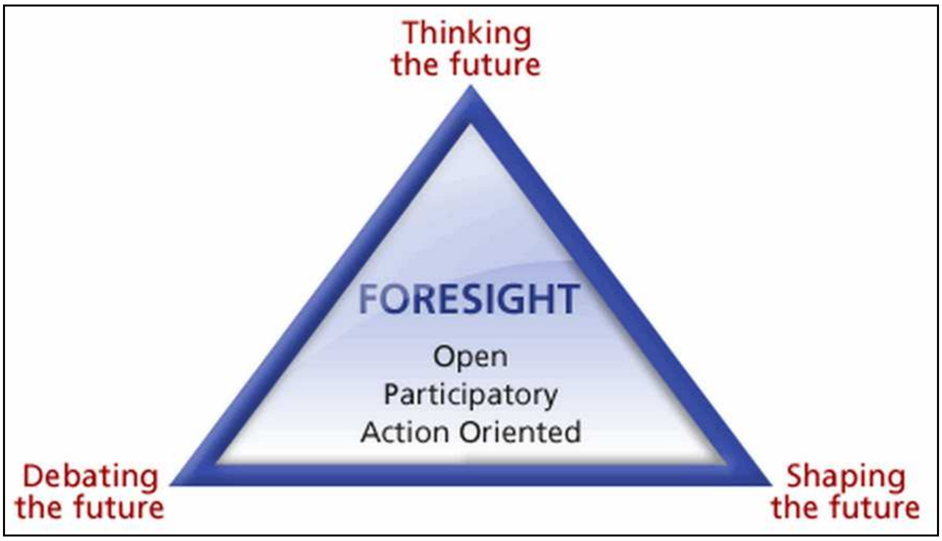


Figure 8. The concept of Foresight methodology (JRC EC 2014)

According to one of the definitions, foresight is a process of the collaboration, discussion and consultation among group of partners leading to the joint refining of future visions and establishing common strategies that guide the opportunities of the long-term development through science, technology and innovation (UNIDO, 2005).
The knowledge and analysis of the present state of science, technology and public awareness, as well as their future medium and long-term interrelations are the basis of Foresight. It serves making online decisions and preparing relevant preemptive actions.

The characteristic feature of foresight work are its collegiality and joint participation because representatives of many group categories (public authorities, science, industry, mass media, non-government organizations, R&D institutions) become involved in open future-oriented discussion. It is also a tool in building the society culture into the thinking of future generations and creates a language of the public debate (Czaplicka-Kolarz [ed] et al., 2007). These groups being familiarized with science, economy and related regulations ensure the correct substantive defining of problems and provide their possible solutions. Foresight studies and assessments ensure high objectivity that stems from a wide participation stakeholders and various experts, and following up numerous aspects (i.e. social, cultural, technological, environmental, economical, political, legal and others), bridging of the internal and external factors, as well as achievable effects.

Foresight and its results provide information about new development trends to policy-making bodies, assistance in establishing of the development strategies and scenarios, road-maps, as well as they help to coordinate activities of various social partners. They may help to create state science, technology and innovation policies and then to implement them.

The goal for foresight projects is researching *possible, probable and preferred versions of the medium and long-term future.* Foresight attempts to predict how the world might look at some point in the future („shaping the future”) in the analyzed area. The vision might be quite different from that being expected assuming present trends influence on how the future will unfold.
Foresight is concerned with the longer term, typically ranging between ten and twenty years, therefore it does not seek to predict: instead, it is a process that seeks to create shared visions of the future, visions that stakeholders are willing to endorse by the actions they choose to take today.
Foresight does not replace forecasting, futures studies, or strategic planning. Each activity has its role, which in many instances can be mutually supportive.

Application of foresight techniques

At first, Japan has been engaging in foresight in the 1970s. During the 1990s, foresight became much more widespread in many countries including European ones. The complexity of the interrelation of the science, technology and society as well as depleting fund sources make it more difficult to take financial decisions. These factors contribute to the increasing popularity of foresight in the governments, R&D and commerce institutions (Wójcicki & Ładyżyński [eds] et al., 2008).

The foresight projects concern many areas in the economy and social life. Among the research directions in which foresight exercises were initiated were energetics on the global, state and regional level, often being correlated to the environmental protection and the use of natural resources. Some foresight exercises deal with such issues as the applications of RES and other alternative energy sources, energy savings and efficiency and clean energy providing systems. The example projects are those being realized in Czech Republic, United Kingdom, and Poland (Czaplicka-Kolarz [ed] et al., 2007; Pyka&Czaplicka-Kolarz [eds] et al., 2011).

An European regional foresight project was done in 2000-2004: the EueEnDel „Europe's Energy System by 2030" in frame of 5th RTD Framework Programme (Velte et al., 2004). The research proved that EU long-term strategy in achieving its energy independence should include considerable RES applications with increased actions for energy savings and efficiency mainly by applying new production technology, energy-efficient buildings with intelligent energy supply systems (Czaplicka-Kolarz [ed] et al., 2007). The above may be recognized as an important evidence that present development actions and foresight for geothermal are also justified. The GEOCOM project just attempted to apply some elements of foresight method for geothermal. Energy foresight for Poland, one of the GEOCOM partners, were done for 2005-2030 (Czaplicka-Kolarz [ed] et al., 2007). This techniques was applied also to elaborate scenarios of „zero emission" energy economics development until 2050 including RES (also geothermal) (Pyka&Czaplicka-Kolarz [eds] et al., 2011).

Basis analytic tools applied in foresight – generals

Methods in foresight exercises

Some group of the main methods are used in foresight exercises. Selecting amongst the methods depends on the type of project and resources, especially time and money. Mostly, some methods is preferred to be use together, being combined in a variety of ways:

1. Exploratory methods (determining of events and extrapolating trends to future),
2. Quantitative methods,
3. Methods identifying key aspects of activities important for strategic planning,
4. Methods based on experts' knowledge,
5. Environmental scanning (diagnosis of the state).
   Systematic analysis of some documentary sources providing information about regional, national and international environment is applied to forecast directions of the future development. These sources may be: data bases, websites, literature, patents, panel discussions of experts.

Some of method groups are presented in table 7.

Expert panels and brainstorming are those which play significant role in foresight exercises.

Foresight projects are applied on various levels: international, national, regional, local, technological.

In case of foresight exercise for the GEOCOM project, expert-based techniques (panels, brainstorming – qualitative/quantitative methods) and environmental scanning were employed (the latter was also used for other WP6.3 tasks). Structural cross-impact analysis was used to interpret obtained research results in the subject.

Table 7. Foresight methods classification (acc. to Wójcicki & Ładyżyński [eds] et al., 2008)

Classification criteria	Examples of methods
1. Exploratory methods	Defining events and setting trends for the future
2. Methods based on experts' knowledge	Delphi methods Expert panels Brainstorming Seminars analyzing development scenarios SWOT analysis
3. Quantitative methods (based mostly on statistical data)	Trends extrapolation Simulation models Cross-impact analysis (MicMac) Dynamic systems
4. Methods identifying key aspects of activities important for strategic planning	Key technologies Dependency tree Structural analysis
5. Environmental scanning methods (diagnosis of state)	Review of available data bases Literature screening Internet searching Review of patents Expert panels

Structural cross-impact analysis – one of foresight research method (MicMac)

Cross-impact analysis is an expert-based method that forces attention to chains of causality to create a matrix of conditional probabilities. This matrix can be subject to mathematical analysis (via specialized software programs) to assign probabilities of occurrence to each of the possible scenarios resulting from the combinations of events.

The use of cross-impact method is one of the various numbers of tools that can be used to organize and interpret subjective knowledge by means of rigorous collective and structured reflection about the interrelations between different elements within a particular system (UNIDO, 2005)).

The MicMac method for structural analysis was used In the GEOCOM project. This software was developed and delivered by Laboratory for Investigation in Prospective Strategy and Organization (LIPSOR). The method and dedicated MicMac software described below are partly based on information in MicMac Version 6.1.2 - 2003/2004 (MicMac, 2014).

Goals of the method

Structural analysis is first of all a tool of structuring the ideas. It gives the possibility to describe a system with the help of a matrix connecting all its components. By studying these relations, the method gives the possibility to reveal the variables essential to the evolution of the system. It is possible to use it alone (as a help for reflection and/or decision making) or as part of a more complex forecasting activity (scenarios).

Decisional structural analysis used as a tool of representation of the players' games is well presented in book L'ABC du pouvoir" (Tenière-Buchot, 1988). The MicMac forecasting method was created by Michel Godet; user of this software can refer to his handbook "L'art et la méthode" (Godet, 2001).

Description of the method

The structural analysis is conducted in three main phases as below:

Phase 1. Considering the variables affecting the development of the analyzed system within a specific time frame
Phase 2. Finding of the relations between the variables and their description – creating the Matrix of Influence
Phase 3. Identification of key variables for evolution of analyzed system in assumed time frame.

The description of the listed phases follows.

Phase 1. Considering the variables affecting the development of the analyzed system within a specific time frame:
The first stage is focused on considering (inventory) all the variables that characterize the studied system (external as well as internal variables). It is recommended at this phase to be as comprehensive as possible and not exclude, *a priori,* any possible path of research. In addition to the expert panels (meetings of collective reflection) and "brainstorming" discussions, it is imperative to extend the collection of variables by unconventional discussions with representatives of possible players of the system that is studied. Detailed explanation of the variables is essential; it will allow a better perception of the relations between these variables further in the analysis. One finally obtains a homogeneous list of internal and external variables of the system; based on experience, it should not exceed 70 to 80 variables.

Phase 2. Finding of the relations between the variables and their description – creating the Matrix of Influence:
In a systemic vision, a variable doesn't exist other than as part of the relational web with the other variables. Also, structural analysis allows to connect the variables in a two-entries table / matrix (direct relations). This Matrix serves as input to define key variables.
This entry of the matrix is generally qualitative: 0 if there is no relation between variables I and J, and 1 in the contrary case. It is however possible to adjust the intensities of the relations (0 = null, 1 = weak, 2 = average, 3 = strong, P = potential).
This phase of entry helps to put for N variables N x N questions (nearly 5000 per 70 variables), of which some would have escaped without such a systematic and comprehensive reflection. This procedure of questioning allows, not only to avoid errors, but also to order and classify the ideas, by creating a common language within the group; it also gives the opportunity to redefine the variables and thus refine the system's analysis.
Every matrix of influence (and mean matrix) already filled up by an exercise player is analyzed by the MicMac software program (also applied for GEOCOM Project). It results in distinguishing some groups of factors. They are as follows:
- **Key factors:** combine high impact with high degree of dependence thus indicating which actions should be given priority in the development of foresight strategic plans,
- **Targets and Results:** evolution of these factors will depend on how other variables of the system will develop,
- **Determinants, motors and brakes (Determinant variables):** have a very strong impact on the system, so they can act as drivers and inhibitors, but are very difficult to control. Knowledge of them is essential in the process of observing long-term trends in the study of the future,
- **Regulating factors, Auxiliary factors:** located near the center of the matrix and can help to achieve strategic objectives, but their effect on the whole system is not decisive,
- **Autonomous factors**: have the least impact on the changes taking place in the system as a whole.

Phase 3. Identification of the key variables for the evolution of the analyzed system in assumed time frame:

Key variables (factors) are the most crucial elements since they can act on the system. They have a high level of influence over behavior and development of the system and a high level of dependency.
Phase 3 consists in identifying the key variables (factors) by the experts; first, by *direct classification* (easy to realize), then by *indirect classification*.

Direct classification:

The total of the connections in a row indicates the importance of the influence of a variable on the whole system (level of direct motricity). The total in a column indicates the degree of dependence of a variable (level of direct dependence).

Indirect classification:

One detects the hidden variables thanks to a program of matrix multiplication applied to an indirect classification. This program allows studying the diffusion of the impacts by the paths and the loops of feedback, and consequently to sort the variables: by order of influence, by considering the number of paths and loops of length 1, 2... N resulting from each variable; by order of dependence, by considering the number of paths and loops of length 1, 2... N arriving on each variable.
Generally, the classification becomes stable after a multiplication of degree 3, 4 or 5.

Potential direct classification:

This is a direct classification that considers the potential relations (meaning that they don't exist now, but which the system's evolution makes probable or at least possible in a more or less near future).

Potential indirect classification:

This is an indirect classification that considers the potential relations.
The comparison of the results (direct, indirect and potential classification) obviously gives the possibility to confirm the importance of certain variables, but also to reveal certain variables which, because of their indirect actions, play a dominating role (and which the direct classification did not allow to reveal). Therefore, the comparison of the hierarchy of the variables in the various classifications, is rich in information.

Analysis of the interrelations among different elements within a particular system is essential for roadmapping and scenario planning being the methods of the final stage of the foresight process.

Advantages of the method

The first goal of structural cross-impact analysis is to stimulate the thinking within the group and to initiate reflection on 'counter-intuitive' aspects of the system's behavior.
It is clear that there isn't just one and "official" reading of the MicMac results, and it's appropriate for the group to move forward the reflection with new interpretations (it's generally the objective of the following phase of the method, the scenarios). In addition, the method presents the advantage to allow a qualitative study of extremely different systems.

Limits of the method

The limits of the method concern the subjective character of the list of the variables established at the first phase, just like that of the relations between the variables, consequently, the interest in communicating with the system's players.
Moreover, the matrix of influences contains relations of very different intensity that have to be considered during the work. Lastly, it is necessary to test the sensitivity of the results for a variation of the input data because these results should never be taken literally but only inviting thinking.

In practice

A structural analysis asks for a work of approximately 6 to 8 months. All depends of course on the rhythm of the working group and the time that it has to devote to the study. An external support is always advised, even though it's not essential, both for the methodology and the subject.

Conclusion to the method

Structural analysis is a tool adapted for a global thinking over a given sector. If 80% of the results obtained are obvious and confirm the first intuition, they specifically give the possibility to put forward the 20% of 'counter-intuitive' results.

Application of structural cross-impact analysis for the GEOCOM research

Objectives, organization of research

In research embraced by the GEOCOM works the elements of foresight approach and structural cross-impacts analysis method (supported by MicMac software; described in previous subchapter) were applied. The main objective was to identify, or at least to gain some idea, on what factors and how might impact geothermal energy uses development and rational energy uses in the GEOCOM countries in future 10-20 years' prospective.

Since seven countries were concerned, the research and its outcomes can be treated as at least done on a regional scale, of mixed strategic-technological type.

The research was done by panel of fourteen experts (appointed by particular GEOCOM teams and some Project partners), some elements of brainstorming discussions were also applied.

The experts represented the wide spectrum of community (the government and local authorities, science, industry and civil society) that was meaningful for the proper research course, following the basic foresight assumptions and obtaining halfway impartial results.

The experts' knowledge (of quantitative and qualitative character) and the environmental scanning being carried out by experts and other GEOCOM Partners were the up-to-date base for the foresight exercises. Then, selection, defining and verification of initial variables of some main groups were done. The data resulting from the scanning of legal regulations, databases, literature and others was also used in the other WP6.3 tasks.
First, all experts invented and suggested the variables (factors) which might affect the geothermal energy uses development in relation to rational use of energy in future 10-20 years' prospective. Considered were several types of variables: political, technological, environmental, economic, social, energy efficiency. After discussions and verification a Final list of 32 factors (classified into 6 types) was composed.
Next, the Matrix of Influences was prepared, the pairs of variables were ranked by the experts, and then analysed by MicMac computer software. As result several groups of factors were distinguished. As third phase of cross-impact analysis, the variables of key importance for the evolution of the analyzed system were identified.

The research done as part of GEOCOM Project attempted to apply (for the first time, most likely) the foresight elements, and obtained results encourage to consider more comprehensive foresight research on geothermal issues in the future.

List of factors selected for structural analysis (MicMac method)

The Final list of factors (table 8) contains the factors that potentially could affect the efficiency of geothermal energy uses and RUE in the GEOCOM countries in the future. It was prepared on the basis of discussions and inputs from the experts. It presents 32 factors (and their descriptions) which may have an impact on the analysed system.
(Further, from among these factors, on the basis on experts' ratings and data processing, there were extracted key factors, determiners, objectives, results and autonomous ones).

Particular factors were ascribed to six main groups (types of factors; table 8), i.e.:
- Environmental,
- Technological,
- Economic,
- Social,
- Political,
- Legal.

These factors were than placed in an **excel file as a Matrix of Influences** and filled by Project experts and partners by ranking the interactions between particular pairs of factors as follows:
0 = no influence,
1 = weak influence,
2 = moderate influence,
3 = strong influence.

Table 8. Final list of factors selected to further cross-impact analysis (MicMac method)

No.	Factor name	Symbolic description	Description	Type of factor
1	Availability of geothermal energy resources	AvaGeoRes	The prevalence (accessibility) energy carrier in the given area is crucial for the applicability of the technology. Technology can be widely applied only when the widely available energy source is used	Environmental
2	Renewability of geothermal energy resources	RenGeoRes	Renewability of resources on a regional scale enables the safe dissemination of technology over sufficient time span	Environmental
3	Possibility of combined cooperation of geothermal energy source with other primary energy carriers in one hybrid source	PosGeoHyb	Possibility of combined cooperation of geothermal with other primary energy sources often gives much better results that systems applying only one primary energy carrier. This contributes to optimi-za tion of energy resources' uses and production at lower costs (-> cheaper energy prices)	Technological
4	Trans-boundary impact of geothermal energy exploitation	CorsBouEx	Unsustainable exploitation of geother-mal reservoirs /covering several states/ may cause local disputes or conflicts	Environmental
5	Costs of geothermal wells' drilling	CostDrill	Cost of drillings may affect economic efficiency of geothermal energy 'mining', its use and the level of exploration and recognition of available resources	Economic
6	Level of public knowledge on possibilities and effects of rational energy use	LevKowRUE	Level of public knowledge on possibilities and effects of rational energy use	Social

7	Consistency of dominating design parameters with available temperature of geothermal resources	ConsDesT	Consistency of heating systems' design standards with available temperature of geothermal resources is of great importance for efficiency of their use. Consistency of design parameters and geothermal resources is referred mainly to temperature: if geothermal resources (water) are at a temperature at least equal as demanded for heat energy carrier then geothermal can be used directly, i.e. without e.g. heat pumps or gas boilers as auxiliary / peaking sources (which significantly increases already high capital expenditures)	Technological
8	Availability of professional manpower specializing in the use of geothermal energy and RUE	StaffGeo	Human resources professional in technology used – number and level of knowledge of available professionals. This factor may reflect in costs and reliability of accessing to and exploitation of energy sources as well as RUE applying	Social
9	Demand for final manufactured form of energy (heat or electricity)	DemFormEn	Demand for final manufactured form of energy - heat or electricity	Technological
10	Mineralization of geothermal water (energy carrier)	MineralGeo	Mineralization of available reservoir fluids may affect the features and attractiveness of geothermal energy resources in two ways: 1. in the case of energy use it may be a serious technical problem; 2. in case of use for recreation and balneotherapy it may be an undeniable asset	Environmental
11	Impact of exploited geothermal water / energy resources on local / regional development, e.g. creating new jobs, enhancing tourism sector	InfluDevel	Start-up of geothermal investments, especially focused on spas and recreation, may help to increase the tourist and recreation offer of a given area/locality. This may result in creation of new jobs and region development	Social
12	Disposal of spent geothermal fluids	DispUsedWat	Disposal of spent geothermal fluids is a big problem especially for large outflows and significant mineralization	Technical and Environmental
13	Financial support for the operational phase	FinSupOper	Financial support for operational phase when energy is sold from geothermal systems (e.g. FiTs, green certificates)	Economic
14	Financial support for the investment phase	FinSupInvest	Financial support for investment phase	Economic
15	Improving the environment	ImprvEnvir	This factor describes the impact of geothermal energy exploitation on the environment. It shall cover all aspects - positive (eg reduction of emissions) and negative (eg pollution of surface water courses by cooled water discharge, emission of gases dissolved in water)	Environmental
16	Energy security of countries and regions	EnSeciurity	Security of energy supplies for countries and regions. Stability and reliability of energy supply. Independence from imported energy carriers	Political and Legal
17	Failure frequency and environmental impact during potential failures	FailFreqImEn	Failure frequency and environmental impact during potential failures	Technical
18	Social acceptability	SocialAccept	Social acceptability of the acquisition and use of energy carrier	Social
19	Level of recognition of the resources	LevRecogRes	Degree of recognition of an energy resource	Technical
20	Global development trends of energy recovery technologies	GlobTrenDev	Global development trends in energy sources' use may contribute to local intensification of use of some energy carriers and technologies of their uses	Political and legal

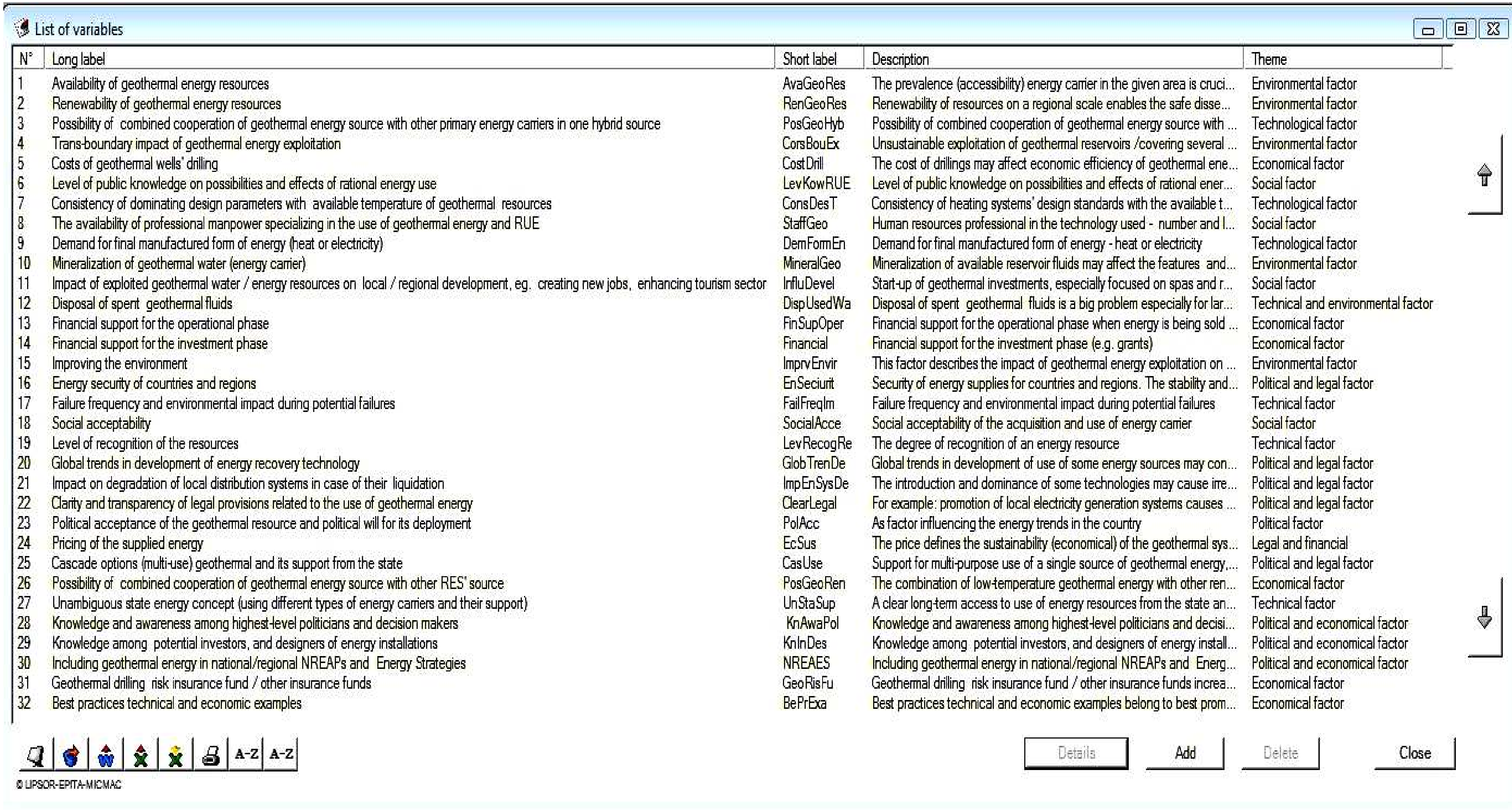
21	Impact on degradation of local distribution systems in case of their liquidation	ImpEnSysDeg	Introduction and dominance of some technologies may cause irreversible changes in the energy distribution system. This can lead to a lot of technical problems in case of desire to return to its original state. E.g.: promotion of local electricity generation systems causes disappearance of national electricity transmission system	Political and Legal
22	Clarity and transparency of legal provisions related to geothermal energy use	ClearLegal	Clarity and transparency of legal provisions related to the use of geothermal energy	Political and Legal
23	Political acceptance of geo-thermal resource and political will for its deployment	PolAcc	As factor influencing the energy trends in the country	Political
24	Pricing of supplied energy	EcSus	Price defines the sustainability (economical) of geothermal system, further development and investments	Legal and Financial
25	Cascaded (multi-use) geothermal uses and their support from the state	CasUse	Support for multi-purpose use of a single geothermal source, use for different purposes (e.g. heat - spa and recreation, heat - agriculture)	Political and Legal Economic
26	Possibility of combined cooperation of geothermal with other RES' source	PosGeoRen	The combination of low-temperature geothermal energy with other renewable energy sources for heat (or electricity)	Technical
27	Unambiguous state energy concept (using different types of energy carriers and their support)	UnStaSup	Clear long-term access to use of energy resources from the state and clear public support for their use	Political and Economic
28	Knowledge and awareness among highest-level politi-cians and decision makers	KnAwaPol	Knowledge and awareness among highest-level politicians and decision makers creates positive climate for legal, fiscal, regulations and give green light for proper investment decisions and market situation	Political and Economic
29	Knowledge among potential investors, and designers of energy installations	KnInDes	Knowledge among potential investors, and designers of energy installations creates an indispensable base for considering geothermal energy as subject of investments and concrete technical design works	Technical
30	Including geothermal energy in national/regional NREAPs and Energy Strategies	NREAES	Including geothermal energy in national/regional NREAPs and Energy Strategies is a sine qua non condition for its development giving a background for decisions on investments	Political and Economic
31	Geothermal drilling risk insurance fund / other insurance funds	GeoRisFu	Geothermal drilling risk insurance fund / other insurance funds increases the will to invest in geothermal projects by limiting the economic and technical risks	Economic
32	Best practices technical and economic examples	BePrExa	Best practices technical and economic examples belong to best promoters of geothermal energy uses development	Economic

Final list of factors (as given in table 8) served to prepare the Matrix of influences. It was done by creating the heads (description) of rows and columns.

Matrix of Influences was filled by 14 experts from the GEOCOM countries: Hungary – 1 Matrix; Italy – 2 Matrixes; Macedonia – 1 Matrix; Poland – 6 Matrixes; Romania – 1 Matrix; Slovakia – 3 Matrixes. The variables listed in table 8 were included to the MicMac software (figure 9) and were subjects of further data processing. Based on obtained data, Mean Matrix of Influences was defined (figure 10).

Mean Matrix of Influences

Mean Matrix of Influences (figure 10) was calculated as arithmetic mean on a bases of data provided in particular Matrixes of Influence filled by individual experts.



N°	Long label	Short label	Description	Theme
1	Availability of geothermal energy resources	AvaGeoRes	The prevalence (accessibility) energy carrier in the given area is cruci...	Environmental factor
2	Renewability of geothermal energy resources	RenGeoRes	Renewability of resources on a regional scale enables the safe disse...	Environmental factor
3	Possibility of combined cooperation of geothermal energy source with other primary energy carriers in one hybrid source	PosGeoHyb	Possibility of combined cooperation of geothermal energy source with ...	Technological factor
4	Trans-boundary impact of geothermal energy exploitation	CorsBouEx	Unsustainable exploitation of geothermal reservoirs /covering several ...	Environmental factor
5	Costs of geothermal wells' drilling	CostDrill	The cost of drillings may affect economic efficiency of geothermal ene...	Economical factor
6	Level of public knowledge on possibilities and effects of rational energy use	LevKowRUE	Level of public knowledge on possibilities and effects of rational ener...	Social factor
7	Consistency of dominating design parameters with available temperature of geothermal resources	ConsDesT	Consistency of heating systems' design standards with the available t...	Technological factor
8	The availability of professional manpower specializing in the use of geothermal energy and RUE	StaffGeo	Human resources professional in the technology used - number and l...	Social factor
9	Demand for final manufactured form of energy (heat or electricity)	DemFormEn	Demand for final manufactured form of energy - heat or electricity	Technological factor
10	Mineralization of geothermal water (energy carrier)	MineralGeo	Mineralization of available reservoir fluids may affect the features and...	Environmental factor
11	Impact of exploited geothermal water / energy resources on local / regional development, eg. creating new jobs, enhancing tourism sector	InfluDevel	Start-up of geothermal investments, especially focused on spas and r...	Social factor
12	Disposal of spent geothermal fluids	DispUsedWa	Disposal of spent geothermal fluids is a big problem especially for lar...	Technical and environmental factor
13	Financial support for the operational phase	FinSupOper	Financial support for the operational phase when energy is being sold ...	Economical factor
14	Financial support for the investment phase	Financial	Financial support for the investment phase (e.g. grants)	Economical factor
15	Improving the environment	ImprvEnvir	This factor describes the impact of geothermal energy exploitation on ...	Environmental factor
16	Energy security of countries and regions	EnSeciurit	Security of energy supplies for countries and regions. The stability and...	Political and legal factor
17	Failure frequency and environmental impact during potential failures	FailFreqIm	Failure frequency and environmental impact during potential failures	Technical factor
18	Social acceptability	SocialAcce	Social acceptability of the acquisition and use of energy carrier	Social factor
19	Level of recognition of the resources	LevRecogRe	The degree of recognition of an energy resource	Technical factor
20	Global trends in development of energy recovery technology	GlobTrenDe	Global trends in development of use of some energy sources may con...	Political and legal factor
21	Impact on degradation of local distribution systems in case of their liquidation	ImpEnSysDe	The introduction and dominance of some technologies may cause irre...	Political and legal factor
22	Clarity and transparency of legal provisions related to the use of geothermal energy	ClearLegal	For example: promotion of local electricity generation systems causes ...	Political and legal factor
23	Political acceptance of the geothermal resource and political will for its deployment	PolAcc	As factor influencing the energy trends in the country	Political factor
24	Pricing of the supplied energy	EcSus	The price defines the sustainability (economical) of the geothermal sys...	Legal and financial
25	Cascade options (multi-use) geothermal and its support from the state	CasUse	Support for multi-purpose use of a single source of geothermal energy,...	Political and legal factor
26	Possibility of combined cooperation of geothermal energy source with other RES' source	PosGeoRen	The combination of low-temperature geothermal energy with other ren...	Economical factor
27	Unambiguous state energy concept (using different types of energy carriers and their support)	UnStaSup	A clear long-term access to use of energy resources from the state an...	Technical factor
28	Knowledge and awareness among highest-level politicians and decision makers	KnAwaPol	Knowledge and awareness among highest-level politicians and decisi...	Political and economical factor
29	Knowledge among potential investors, and designers of energy installations	KnInDes	Knowledge among potential investors, and designers of energy install...	Political and economical factor
30	Including geothermal energy in national/regional NREAPs and Energy Strategies	NREAES	Including geothermal energy in national/regional NREAPs and Energ...	Political and economical factor
31	Geothermal drilling risk insurance fund / other insurance funds	GeoRisFu	Geothermal drilling risk insurance fund / other insurance funds increa...	Economical factor
32	Best practices technical and economic examples	BePrExa	Best practices technical and economic examples belong to best prom...	Economical factor

Figure 9. The screen shot of key variables definition, MicMac software for cross-impact analysis method

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1		1. AvaGeoRes	2. RenGeoRes	3. PosGeoHyb	4. CorsBouEx	5. CostDrill	6. LevKowRUE	7. ConsDesT	8. StaffGeo	9. DemFormEn	10. MineralGeo	11. InfluDevel	12. DispUsedWat	13. FinSupOper	14. FinSupInvest	15. ImprvEnvir	16. EnSeciurity	17. FailFreqImEn	18. SocialAccept	19. LevRecogRes	20. GlobTrenDev	21. ImpEnSysDeg	22. ClearLegal	23. PolAcc	24. EcSus	25. CasUse	26. PosGeoRen	27. UnStaSup	28. KnAwaPol	29. KnInDes	30. NREAES	31. GeoRisFu	32. BePrExa
2	1. AvaGeoRes		2	2	2	2	1	2	2	2	1	3	2	2	2	3	3	0	2	2	2	1	1	2	2	2	2	2	1	2	2	2	2
3	2. RenGeoRes	2		1	2	1	1	1	1	1	1	2	2	2	2	3	2	1	1	1	2	1	1	1	2	1	2	2	1	1	2	1	2
4	3. PosGeoHyb	1	1		0	1	2	2	1	2	1	2	1	2	2	2	2	1	2	1	2	2	1	1	2	2	2	2	1	2	2	1	2
5	4. CorsBouEx	1	1	0		1	2	1	1	1	0	2	1	1	1	1	2	1	2	2	1	1	1	2	1	1	1	1	1	1	1	1	1
6	5. CostDrill	1	0	2	1		1	1	2	1	1	1	2	1	3	1	1	1	2	2	1	1	1	2	2	1	1	1	2	2	2	2	2
7	6. LevKowRUE	1	1	1	1	0		0	1	1	0	1	1	1	1	2	1	0	3	1	1	1	1	2	1	1	1	1	2	1	1	1	1
8	7. ConsDesT	1	1	3	1	1	1		1	2	1	2	1	1	1	2	1	1	1	1	1	1	1	1	2	2	3	1	1	2	2	1	2
9	8. StaffGeo	1	1	2	1	2	2	1		1	0	1	1	1	1	2	1	2	2	2	2	1	1	1	1	2	2	1	1	2	1	1	2
10	9. DemFormEn	1	1	2	1	2	1	2	1		0	2	1	2	2	2	2	1	2	2	2	1	1	1	2	2	2	1	1	2	1	1	1
11	10. MineralGeo	1	1	2	1	1	1	1	0	1		2	3	1	1	2	1	2	1	1	1	1	1	1	1	2	1	0	1	1	1	1	1
12	11. InfluDevel	1	1	2	1	1	2	1	2	2	1		1	2	2	2	1	1	3	2	1	1	1	2	1	1	1	2	2	2	1	1	2
13	12. DispUsedWat	2	2	1	2	1	1	1	1	1	1	2		1	2	3	1	1	2	1	2	1	2	2	1	2	1	1	1	2	1	1	2
14	13. FinSupOper	1	1	2	1	1	1	1	1	1	1	2	1		2	2	1	1	2	1	1	1	1	1	2	1	2	1	1	2	1	1	2
15	14. FinSupInvest	1	1	2	1	2	1	1	1	2	1	2	2	2		2	2	1	2	2	1	1	1	1	2	2	2	2	1	1	1	2	2
16	15. ImprvEnvir	1	1	1	1	0	2	1	1	1	1	2	2	1	1		1	0	3	1	2	1	2	2	1	1	1	2	2	1	2	0	2
17	16. EnSeciurity	1	1	1	1	0	2	1	1	2	0	2	1	2	2	1		1	2	1	2	1	2	2	2	1	2	1	2	2	2	1	2
18	17. FailFreqImEn	1	1	1	1	1	1	1	1	1	1	2	1	2	2	2	1		2	1	1	1	1	2	1	1	1	1	1	2	1	1	2
19	18. SocialAccept	0	1	2	1	0	2	1	1	2	0	2	1	1	1	2	1	1		1	1	1	1	2	1	1	1	1	2	2	1	0	1
20	19. LevRecogRes	1	1	1	1	1	2	1	2	1	1	2	1	1	2	1	2	1	2		1	0	1	2	1	1	1	1	2	2	1	1	1
21	20. GlobTrenDev	1	1	2	1	1	2	1	2	2	1	2	1	1	2	2	2	1	2	1		1	1	2	2	2	2	1	2	2	2	1	1
22	21. ImpEnSysDeg	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	2
23	22. ClearLegal	1	1	1	1	1	2	1	1	1	1	2	1	2	1	2	1	1	2	1	1	0		2	2	1	1	2	2	2	2	2	2
24	23. PolAcc	1	0	1	2	1	1	1	1	1	0	2	1	2	2	2	2	0	2	2	1	0	2		2	1	1	2	2	2	2	2	2
25	24. EcSus	1	1	2	1	2	1	1	1	2	1	2	1	2	2	1	1	0	2	1	2	1	1	2		2	2	2	2	2	2	1	2
26	25. CasUse	1	1	2	1	1	1	2	2	2	1	2	1	2	2	2	1	1	2	1	2	1	1	1	2		2	1	1	2	1	1	2
27	26. PosGeoRen	1	1	2	1	1	2	2	2	1	0	1	1	2	2	2	1	1	2	1	2	1	1	1	2	2		1	2	2	2	0	3
28	27. UnStaSup	1	1	2	1	1	2	2	1	2	1	2	1	2	2	2	2	1	2	2	2	1	2	2	2	1	1		2	2	2	1	2
29	28. KnAwaPol	1	1	2	2	1	1	1	2	2	1	1	2	2	2	2	2	1	2	2	2	1	2	3	2	1	2	2		2	2	2	2
30	29. KnInDes	1	1	2	1	1	1	1	2	2	1	2	1	1	1	2	1	1	1	2	2	1	2	1	1	2	2	2	2		1	1	2
31	30. NREAES	1	1	2	2	1	1	1	2	2	1	2	1	2	2	2	2	1	2	2	2	1	2	2	2	1	1	2	2	2		2	2
32	31. GeoRisFu	1	1	1	1	2	1	0	1	1	1	2	1	1	3	1	1	1	1	2	1	0	1	1	2	1	1	1	1	2	1		1
33	32. BePrExa	1	1	2	2	1	2	1	2	1	1	2	2	2	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2	2	1	

Figure 10. The Mean Matrix of Influences (based on Matrixes of Influence fulfilled by individual experts). MicMac software calculations.

Results of structural analysis

Graphic presentation of structural analysis' results (MicMac method)

Based on data processed by MicMac software, several maps and graphs on direct and indirect influence/dependence presenting the results of structural analysis were developed:

- Direct influences – dependences map (figure 11);
- Based on positions of particular factors on direct influences-dependences' map, they were assigned into several groups (figure 12) – this is a main graph resulting from applying the

structural analysis method for GEOCOM research objectives. It indicates location of each from 32 variables concerned and strengths of relations among them. It points out Key factors,

- Determinants, motors and brakes, as well as other groups of factors which potentially will affect the development and efficiency of geothermal energy uses in the context of RUE in the future;
- Direct influences graph (figure 13);
- Displacement map: Direct–Indirect influence/dependence graph (figure 14).
  When the differences among direct and indirect influences/dependences are significant it may happen that the boundaries of the division factors cannot be unambiguously. It should be checked out – figure 8 shows the displacements and the figure 9 shows the factors' identification on the displacements graph. One may notice that results do not differ so much from the factors indicated previously.

In case of variable "Renewability of geothermal energy resources" (RenGeoRes) its position on the graph resulted from MicMac processing (figure 12) was shifted and included manually to the group "Determinants, motors and brakers" (as more proper since in experts' discussion it was agreed that it was more Determinant than Autonomous factor (only renewability of resources makes it possible to achieve success in projects related to geothermal energy development in long-term scale – so it "determines" the possibility of its use).

Identify basic groups of factors

Interpretation of results of cross-impact structural analysis was done on the basis of dependence / influence maps and graphs (figure 11–15). It allowed to identify the factors which may impact future geothermal energy uses development and promotion in the GEOCOM countries and classify them into several groups: key factors, targets, results, determinants, motors and breaks, regulating factors, auxiliary factors, autonomous factors. They can be presented as follows:

Key factors (which will have the most significant impact if and how geothermal energy uses in the GEOCOM countries will develop in the future and the factors which should be given priority in the development of foresight strategic plans) – represent political, legal and economic types (wherein some factors were assigned to two types):

Political

- Including geothermal energy in national/regional NREAPs and Energy Strategies
- Knowledge and awareness among highest-level politicians and decision makers

Political & legal

- Global trends in development of energy recovery technology

Political& economic

- Unambiguous state energy concept (using different types of energy carriers and their support).
- A clear long-term access to permit for use energy resources from the state and clear system of public support for their use

Economic

- Best practices technical and economic examples
- Knowledge and awareness among highest-level politicians and decision makers

Targets (evolution of these factors will depend on how other variables of the system will develop. They also indicate what items, activities, provisions should be considered / realized to contribute to development of geothermal energy) – this group is particularly reach and includes 17 factors (53% of all factors concerned) of wide spectrum of types, i.e. political, legal, social, as well as many factors of economic and technology types (some variables were assigned to two types):

Political
- Energy security of countries and regions

Political& legal
- Cascade options (multi-use) geothermal and its support from the state
- Energy security of countries and regions
    - Pricing of the supplied energy

Economic
- Geothermal drilling risk insurance fund / other insurance funds
- Cascade options (multi-use) geothermal and its support from the state
- Impact of exploited geothermal water / energy resources on local / regional development, e.g. creating new jobs, enhancing tourism sector
- Financial support for the investment phase
- Pricing of the supplied energy

Technology
- Possibility of combined cooperation of geothermal energy source with other primary energy carriers in one hybrid source
- Level of recognition of the resources
- Cascade options (multi-use) geothermal and its support from the state
- Knowledge among potential investors, and designers of energy installations
- Demand for final manufactured form of energy (heat or electricity)
- Possibility of combined cooperation of geothermal energy source with other RES' source

Social
- Impact of exploited geothermal water / energy resources on local / regional development, e.g. creating new jobs, enhancing tourism sector
- Availability of professional manpower specializing in the use of geothermal energy and RUE

Results (as in case of Targets group, evolution of these factors will depend on how other variables of the system will develop) – this group contains political, social and environmental factors:

Political
- Political acceptance of the geothermal resource and political will for its deployment

Social
- Social acceptability

Environmental
- Improving the environment

Determinants, motors and brakes (have a very strong impact on the system, so can act as drivers and inhibitors, but are very difficult to control. Knowledge of them is essential in the process of observing long-term trends in the study of the future) – this group is represented by (only) two factors of *environmental* type:
- Availability of geothermal energy resources
- Renewability of geothermal energy resources.

This result points out sound role of "renewability" of geothermal energy, and – as one may suspect – several other features related to this adjective (e.g. local, clean, independent, assuring safety of supply, etc.) essential to develop both geothermal as well as other renewable sources of energy.

Regulating and Auxiliary factors (can help to achieve strategic objectives, but their effect on the whole system is not decisive) – these groups contains several factors of political, legal, economic, technology, environmental and social types:

Political& legal:
- Clarity and transparency of legal provisions related to the use of geothermal energy

Economic

- Costs of geothermal wells' drilling
- Financial support for the operational phase
  (while Financial support for the investment phase was ascribed to Targets)

Technology

- Consistency of dominating design parameters with available temperature of geothermal resources
- Disposal of spent geothermal fluids

Environmental

- Disposal of spent geothermal fluids

Social:

- Level of public knowledge on possibilities and effects of rational energy use

Autonomous factors (have the least impact on the changes taking place in the system as a whole) – three factors were designated to this group:

Political& legal:

- Impact on degradation of local distribution systems in case of their liquidation

Technology

- Failure frequency and environmental impact during potential failures

Environmental

- Mineralization of geothermal water (energy carrier).

Main findings resulting from structural cross-impact analysis

The research described above attempted to apply the approach of foresight method and elements of structural cross-impact analysis in order to gain an insight into main factors that will impact and control the geothermal energy uses development in RUE context in the GEOCOM countries in the future. Even if the research was a kind of preliminary and very limited exercise, it did indicate for the complexity and importance of several various factors for the development in question. Moreover – it gave some thoughts as to the actions and direction which shall be considered if we are willing to enhance geothermal energy uses development and make it competitive with other conventional and RES sources.
Specially interesting was to indicate and learn Key factors, Determinants an Targets.
It seems that analysis and results pointed out the key factors and targets (even intuitively) are and will be important in the future, and many play such a role also now.
The key factors – are essentially of political, legal types (!), not technological or environmental as one might initially expect. The expectation are pierced on the need to change the situation with regard to these factors, as well as better awareness among top politicians and decision makers in many countries in order to create proper political and legal environment for geothermal energy deployment in many GEOCOM countries (because without this element there will be a real development).
In it also worth to point out that to the key factors' group there were included "Best practices technical and economic examples" (*BePrExa*). They were also included as crucial component (Demo-sites examples) into the GEOCOM Project and its main objectives.

In case of Determinants, motors and brakes, two factors only of environmental type were identified: availability of geothermal energy resources and renewability of geothermal energy resources.
However, one might expect that more factors of another types would be shown up in this group (political, legal, economic, technology), specially taking into account initial objective and expectations as to cross-impact analysis in GEOCOM works. For example – one could expect that some factors (political, legal, economic) now regarded as shortages or barriers (i.e. "brakes") for geothermal

development (vide e.g. subchapters 4.2, 4.3) would be included into this group. Instead, they were placed in Targets, what may be interpreted that in the future they shall be treated as subjects of concrete relevant actions which need to be taken to remove them thus paving the way to achieve for geothermal energy development in the GEOCOM countries.
These results may also suggest that, in addition to the factors included to this group directly by MicMac analysis, another factors shall be arbitrary included here by the experts.

As already mentioned, the group of targets identified is particularly reach, covering 17 factors (53% of all concerned) of different types: political, legal, social, economic, technological ones (some variables were assigned to two types). This relatively large and diversified group confirms and indicates that several important items, activities, provisions should be considered and realized in order to achieve the assumed objective, i.e. the development of geothermal energy and RUE in the GEOCOM countries.
Indicating some factors included into the targets, which confirmed also the purposefulness and "future thinking" of the GEOCOM Project's initiators and partners: the application of cascaded systems in geothermal was classified *(CasUse)* as one of the targets which should be pursued (this factor was placed in the GEOCOM topic itself (!)). To the same group of factors another variable related to the main theme of the project was assigned (*PosGeoHyb)* - possibility of combined cooperation of geothermal energy with other primary energy carriers in one hybrid source. It describes the possibility of integration with other sources of geothermal energy.

As one of target and auxiliary factors, the variables of social types were identified, what confirmed their role for geothermal and RUE sector (as also pointed out and treated by another GEOCOM work: "Public perception and understanding of geothermal energy" (www.geothermal communities.eu).

In case of autonomous factors, the cross-impact method indicated the lack of negative impact on degradation of local distribution systems in case of their liquidation *(ImpEnSysDeg)* on the development of geothermal district heating. Also the failure frequency and environmental impact during potential failures was included into this group. It may be interpreted that listed factors were defined in this group also because such cases had been not frequent so far, rather incidental, are not known in general and, most likely, are expected not to have larger impact /specially that innovative and improved technologies minimizing potential negative impacts are expected in the future).

To sum up – application of foresight approach and elements of structural cross-impact analysis method for part of GEOCOM research works facilitated to identify essential factors (and their types) that may impact the future development of geothermal energy and its rational use. The MicMac method confirmed in a more objective way some key assumptions which were pointed out in the theme of the GEOCOM Project itself (!).

One may recommend to consider application of foresight approach for future more comprehensive research dedicated to geothermal energy uses, RUE etc. items (specially that EU members states are more and more experiencing many challenges resulting from current and predicted energy and political situation).

Resulting set of key factors may suggest a strong influence of political and legal factors of future geothermal energy development. Significant is also the group of targets (technological, economic, social), which indicates that in this area the focus will be necessary to achieve the assumed objective (i.e. development of mentioned sector.
The results were also useful to suggest some actions and solutions which could contribute to facilitate and improve current and future conditions for geothermal deployment ("shaping the future").

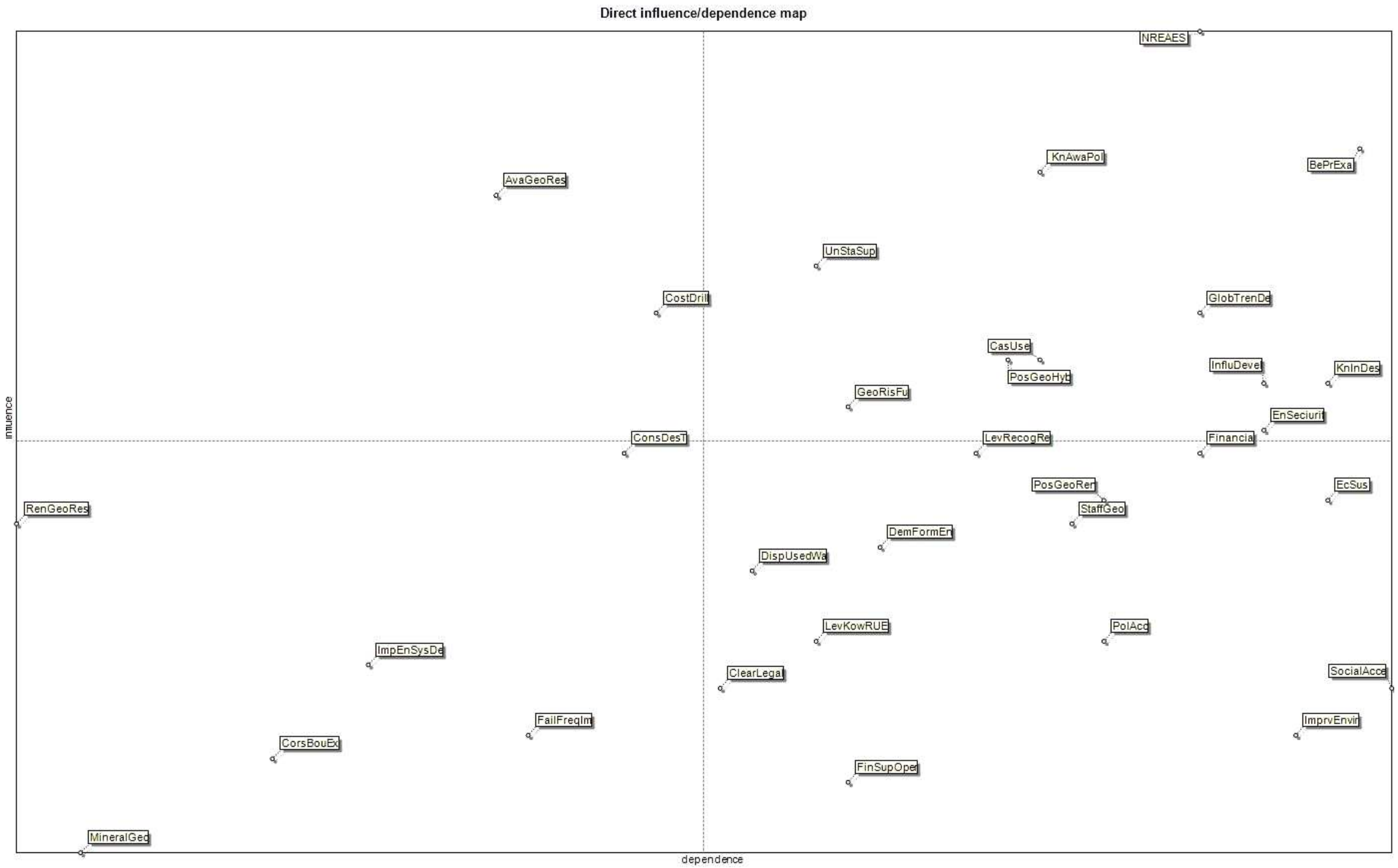


Figure 11. Direct influences-dependences graph. MicMac software calculations.

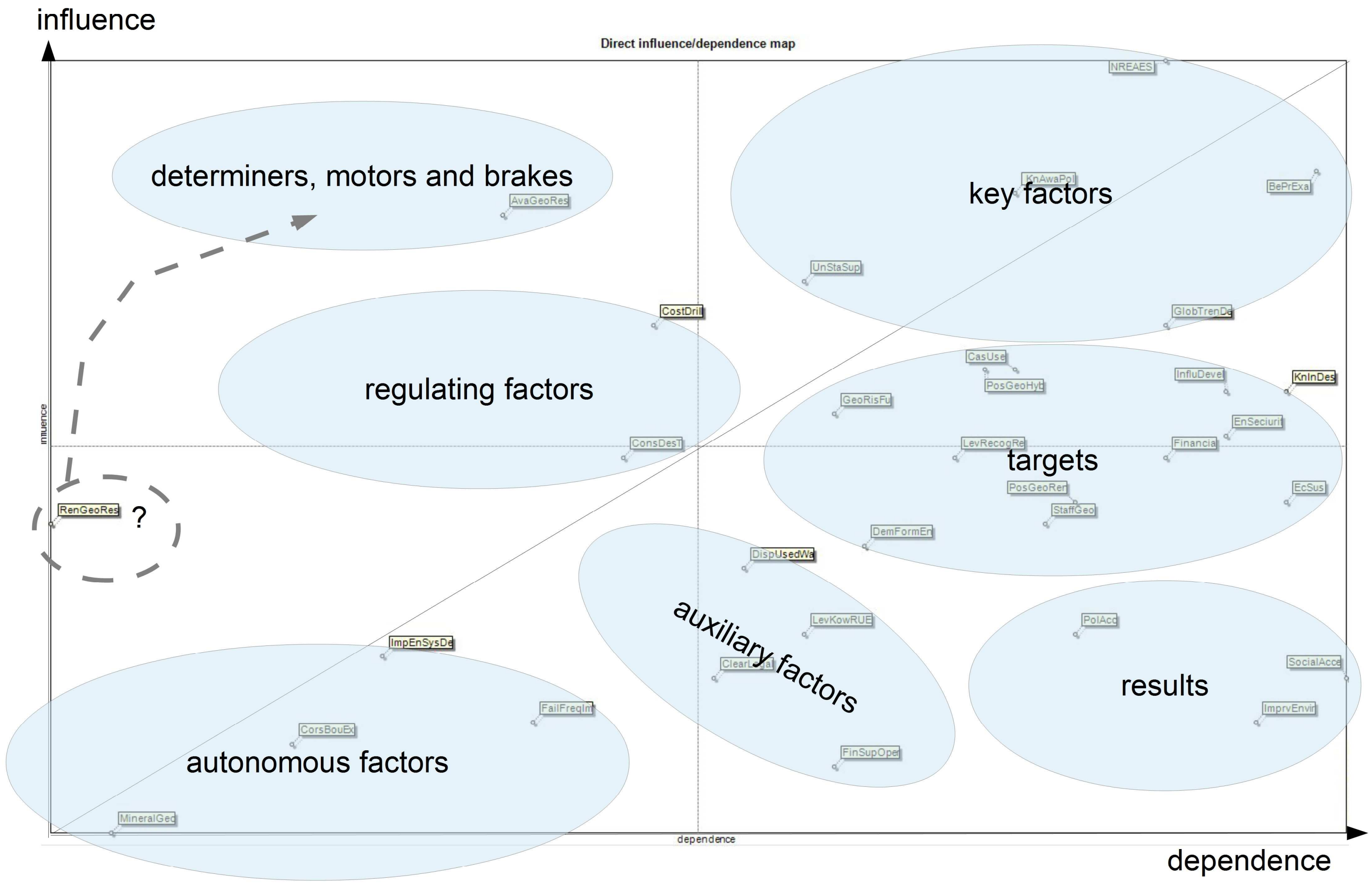


Figure 12. Allocation of analyzed factors to particular main groups. MicMac software calculations.

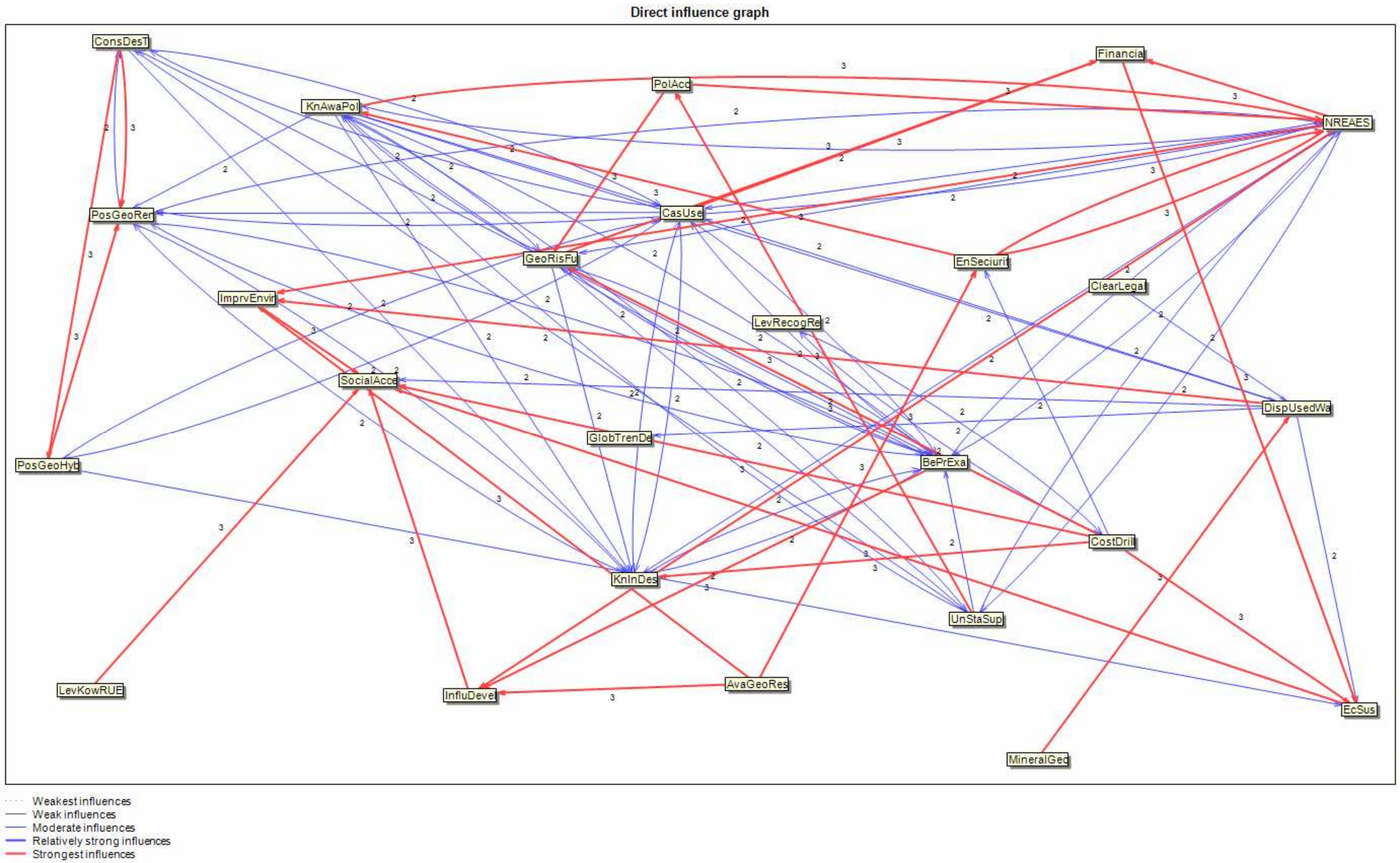


Figure 13. Direct influences graph. MicMac software calculations.

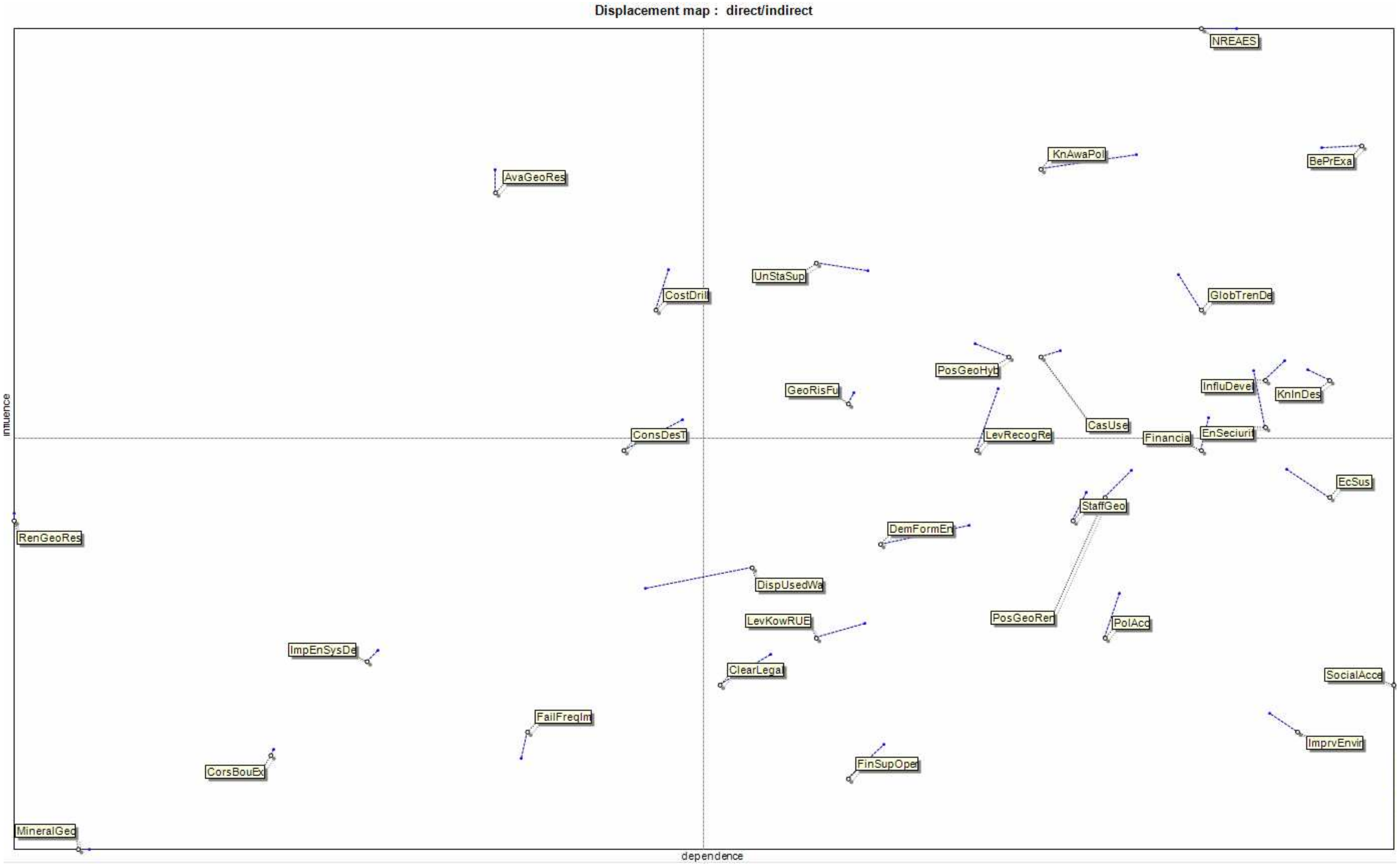


Figure 14. Displacement map of direct/indirect influences/dependences. MicMac software calculations.

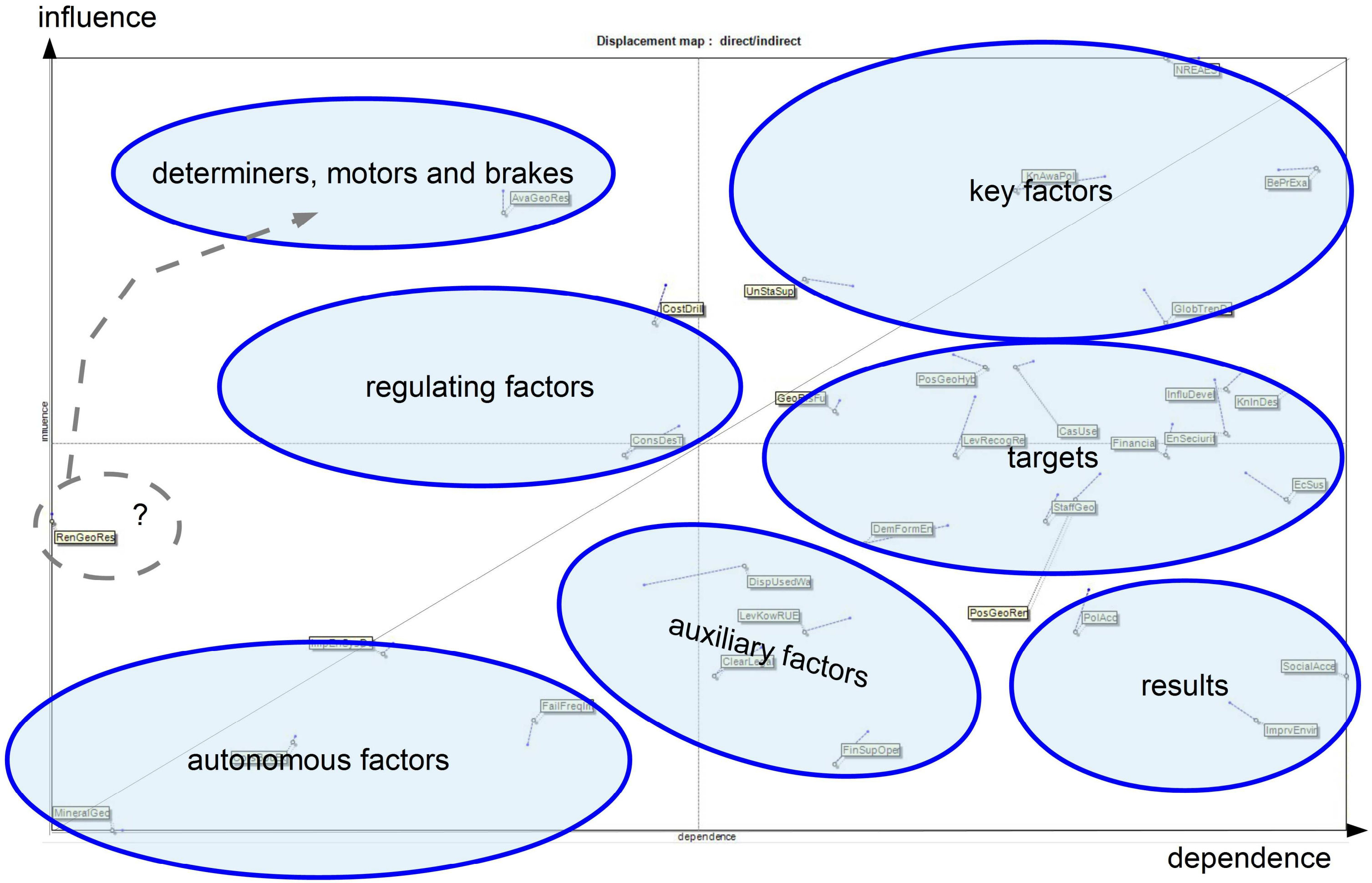


Figure 15. Factors identification on displacement map: direct-indirect influences/dependences. MicMac software calculations.

5. Conclusions and recommendations

- Many European countries possess prospective geothermal energy resources. In that group are Central and Eastern European countries embraced by the GEOCOM works. In fact, they are fortunate to have several of the best geothermal aquifers in Europe (including the Larderello area, Pannonian basin, Inner Carpathian basin. This potential is suitable for many applications, also as cascaded systems, in integration (hybridization) with other energy sources (both traditional and other renewables). Among several positive effects and benefits of geothermal energy one shall point out the fact that its introduction into new or existing energy systems increases their efficiencies and facilitates application of modern technologies. Not mention other aspects, related to realization of important objectives and targets included in national and EU-energy policies and directives.

- To increase geothermal uses, several actions and measures should be introduced in order to place it on a market playing ground with other energy carries, including other RES much more stronger promoted and lobbied. Such tools shall be implemented on the basis of prior identification of essential factors and conditions that control the geothermal development and related rational use of energy. The research done for the GEOCOM countries resulted in identification of several economic and environmental factors that control current situation and can be regarded as constraints, market drivers and best practices of the geothermal energy development and related rational use of energy. These factors were defined and analyzed by the professionals and experts well familiar with the specifics of geothermal sector.

The outcomes of the research works allow to conclude the following current picture of the main financial shortages and constraints for geothermal uses development and rational energy use in the GEOCOM countries:

- The availability of various financial support measures (from national and EU-sources and programs) for geothermal uses' development in the GEOCOM countries is very moderate (or is even more proper to write that poor) specially when comparing with other renewable energy sources both in case of heat and electricity production. In addition, in almost all cases, the existing measures were not tailored specially for geothermal energy but for the whole RES sector and geothermal can be among the beneficiaries if it meets their general provisions. It is illustrated by some kind of "statistics": from among analyzed 12 financial tools, relatively many (50 – 60%) are available in Italy and Hungary. The worst situation is in Romania and Slovakia (only 2 types of measures existing). Other three countries (Poland, Macedonia, Serbia) have a kind of intermediate, but also not satisfactory situation.

- What can be stated without any doubts and what proves the advantages of geothermal energy in comparison with other RES is that, despite higher investment costs, it guarantees a continuous production through the year, with a capacity factor near to 1. As a matter of fact 10 MWe of geothermal installed electric capacity are equivalent to 40–50 wind power MWe (!).

- Among the GEOCOM states, Italy is a positive exception – several financial and fiscal tools operational there shall be proposed to replicate and transfer to other Project countries as best practice solutions.

- One shall specially point out the lack of subsidies for geothermal drillings and Geological Risk Insurance Funds in all GEOCOM countries (with some exception of Hungary).

- *Experiences and analyses of environmental, water protection, sustainability issues* in the GEOCOM countries have indicated that there are almost no negative impacts of these elements for geothermal energy uses' projects and activities.
  In particular, the main focus is paid on the injection - the best method of disposal of spent geothermal fluids for many reasons (including long-term sustainable management of the reservoir and protection of surface waters). Injection offers also an alternative for expensive geothermal waters' treatment processes.
  However, except for Italy, such an obligation is not required by main codes and laws in the GEOCOM countries (but on case by case basis in some states). Moreover, it demands for proper financial support and measures as pointed out by some GEOCOM Partners (e.g. Galanta pilot-site, Slovakia). Some support is provided in Italy – to "incentivise" injection)

- One shall also notice that soon an increased attention has to be paid on the conditions and terms of injection of spent geothermal water (and increasing need to apply it) – in the forthcoming years this will be even more concerned than now because of provisions of the European Frame Water Directive, and other EU- and national implementation documents.

- In addition to the specified above, the experts involved in the GEOCOM research paid attention on some other constraints for geothermal development in the Project countries, namely:
  - Unstable legal environment related to injection (required/not required), changeable energy policies and subsidizing of some energy carriers which do not favor the geothermal industry development in some countries (e.g. Hungary, Poland);
  - Technological-economic constraints concerning geothermal technologies: these technologies (especially for heat and cold applications) would not yet survive in the current market if not adequately incentivised, then currently the great environmental benefits offered by these technologies do not go hand in hand with those economics.

- The reported research revealed some best practice solutions in geothermal energy and rational energy uses sectors existing in the GEOCOM countries (mainly in Italy and Hungary, in single cases in Slovakia, Poland) which may be recommended or transferred among the countries, especially of fiscal and economic character: fiscal measures for consumers; investment subsidies for geothermal projects: financial subsidies. Best practices of environmentally-related regulations and solutions were also underlined.

- In addition to several best practice examples existing in the GEOCOM countries, some solutions from other European countries were recommended to urgently consider by the Project states, as being of essential importance for making a real progress in geothermal uses deployment:
  - Establishing the Geological Risk Guarantee Funds for geothermal drillings,
  - Introducing public subsidies for geothermal drillings (specially first well), in particular if dedicated for energetic purposes.

- In respect to economic viability and cost-effectiveness of geothermal projects in relation to abatement /reduction of CO_2 eq emissions, the suggestion was made that it would be of purpose to elaborate and introduce into wider practice a common methodology for evaluation the cost-effectiveness of geothermal projects in relation to avoidance /reduction of CO_2 emissions.

- Similar suggestion was made as to purposefulness and need to elaborate and put into wider practise a common objective methodology for evaluation unit CO2 reduction / abatement emission costs in case of replacement by geothermal (and other renewables) other fossil fuels in heating and power generation sectors. Such methodology shall consider geothermal specifics and assumptions applied in prognostic works (e.g. by Wesselink&Deng, 2009; McKinsey&Company, 2009a). Indeed, a common tool is indispensable to compare the situation in particular countries, in Europe and globally. Such well-tailored tool is important specially that preliminary analyses indicate that in some cases geothermal energy even now presents relatively low unit CO2 reduction costs thus giving promising prospects for the future, too. One may expect that such methodological tool would help to indicate and to prove that geothermal energy belongs to the most effective and low-costs options to limit the CO2'GHG emissions on the way to low-emission energy economy.

- Looking in longer term – the research and analyzes applying foresight methodology approach and cross-impact analysis confirmed in the conviction that a number of factors that had been identified as the present constraints and best practices, would control and impact future development of geothermal energy and rational energy uses. It is therefore necessary to take appropriate actions, reduce barriers and implement measures that will facilitate the truth development of this prospective sector now and in the future.

- One might consider exact profound foresight technique for comprehensive strategy dedicated to geothermal energy development, rational energy uses, etc. items. Specially that the GEOCOM as well as other European states are more and more experiencing many challenges resulting from current and predicted energy and political situation and such research would be of purpose. Some attempts in relation to renewables and geothermal energy exist, they could be used as seed money for a possible concept.

- In addition to the above statements one can point out that several particular issues, topics and outcomes presented in this Report shall be treated not as completed tasks, but rather as their identification, opening, indicating their importance and role in making a real progress in geothermal energy applications and rational energy uses in the GEOCOM countries (and even in other European states). Therefore there is a need to initiate further more dedicated and comprehensive studies, elaborate specific methodologies, etc. since several issues essential for geothermal sector have been not studied or treated with sufficient attention yet. The GEOCOM research summarized in this Report have vindicated somehow the deficiencies and needs still existing and worth of future interest.

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http://www.unido.org/file-storage/download/?file_id=45322
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www.geofar.eu
www.geothermalcommunities.eu
www.geothermalcommunities.eu/downloads

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Annex 1

List of main legal acts and regulations related to geothermal water/energy exploration, exploitation and uses

Hungary:

Act XLVIII of 1993 on Mining (and its upgrades)
„The purpose of this Act is to regulate the mining of mineral raw materials, prospecting for and exploitation of geothermal energy, the establishment and operation of pipelines conveying hydrocarbon, and the activities related thereto, in harmony with the protection of life, health, security, the environment and property, and the management of mineral and geothermal Energy resources."
Sections 1., 3., 5., 8., 9., 14., 15., 20., 22., 22/B., 44., 45., 49. regulate the exploration, exploitation and the use of geothermal energy.
Regulation of land concession in the Act on Mining: the whole Part II of this act referring with the concession contracts. Sections: 8., 9., 10., 11., 12., 13., 14., 15., 18. and 19.

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„In order to define the fundamental rights and responsibilities related to water utilization, the preservation of alternatives for water utilization, and the prevention of damage caused by water, taking into consideration the requirements of environmental protection and nature conservation, Parliament enacts the following Act"

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The aim of this Decree is to determine the tasks, rights and obligations associated with: a) the ensuring and maintaining of the good status of groundwater; b) the progressive reduction and prevention of the pollution of groundwater; c) a sustainable water use based on the long-term protection of available groundwater resources; d) the remediation of the geological medium.

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This is a contribution (called water resources fee) to be paid to the central budget on all water utilizations. In the case of surface waters, for example in a water plant or regarding water used for irrigation, and in the case of underground waters, e.g. drinking water, bathing water, etc., the basis for the contribution is the water volume actually used as determined by measurement and the water fee (HUF/m3) which is identical in each water application, but because of the different multiplication factors, significant differences arise among the various utilization approaches.
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• Government Decree No. 220/2004. (VII. 21.) Korm. on the protection of surface water quality
• Government Decree No. 221/2004. (VII. 21.) Korm. on certain rules of river basin management
• The Government Decree No. 314/2005. (XII. 25.) Korm. on environmental impact assessment and the unified environmental use permits
• Government Decree No. 27/2006. (II. 7.) Korm. on the protection of waters against pollution caused by nitrates of agricultural sources

Italy:

- D.M. 06-07- 2012 (Ministry of Economic Development) "Implementation of the art.24 of the legislative decree 3 March 2011 n.28, containing incentives for the production of electricity from renewable sources not-photovoltaic"

- Direttiva 01-07-2011 (Ministry of Economic Development) "Directive for the first implementation of the modifications introduced by the Legislative Decree 28/2011 to the Legislative Decree 22/2010 for the reorganization of the legislation on exploration and exploitation of geothermal resources for matters pertaining to the Ministry of Economic Development"

- D. Lgs. 03-03-2011 n.28 "Implementation of the directive 2009/28/CE on the promotion of the use of energy form renewable sources, containing modification and following abrogation of the directives 2001/77/CE and 2003/30/CE"

- D. Lgs 03-04-2006 n.152 "Environmental regulations"

- D. Lgs. 29-12-2003 n.387 "Implementation of the directive 2001/77/CE concerning the promotion of power generation from renewable energy sources within the national electricity market"

- Lgs. 11-02-2010 n.22 "Reorganization of the legislation on exploration and exploitation of geothermal resources, according to the art. 27, clause 28, of the law July 23 2009, n.99"

- D.P.R. 08-08-1994 n. 485 "Regulations governing the procedures of issuing an exploration permit and mining lease of national interest geothermal resources"
- D.P.R. 27-05-1991 n.395 "Approval of the implementing law of the December 9 1986 n.896 law, concerning regulations for the exploration and exploitation of geothermal resources"
- Article 826 of the Italian Civil Code, concerning properties of the State, Provinces and Municipalities
- R.D. 11-12-1933 n.1775 "Law on legal provisions on water and electrical systems"
- R.D. 29-07-1927 n.1443 "Legislative rules framework to govern the mines exploration and exploitation into the kingdom".
- Agreement Protocol 20-12-2007 "General Agreement on Geothermal Energy" exploitation in Tuscan power plants
- 20-04-2009 "Voluntary agreement for the implementation of the Agreement Protocol of 20-12-2007 known as General Agreement on Geothermal Energy"
- Tuscany Region Law 24-02-2005 n.39 "Provisions concerning Energy"
- Tuscany Region Law 12-02-2010 n.10 "Regulations concerning Strategic Environmental Assessment (VAS), Environmental Impact Assessment (VIA) and Environmental Effects Assessment"

Macedonia:

- The Energy Law (Official Gazette of Republic of Macedonia No.16/11, 136/11, 79/13) is the central energy regulatory act.
- Strategy for the development of the energy sector in the Republic of Macedonia until 2030 (Official Gazette of Republic of Macedonia No.61/10). According to the Strategy, the RES share in total energy use in Macedonia will increase from 13.8%)in the year 2005 to 21% in the year 2020.
- Strategy for use of RES in the Republic of Macedonia until 2020 (Official Gazette of Republic of Macedonia No.125/10).
- The ordinance on the licenses for performance of energy activities (Official Gazette of Republic of Macedonia No.143/11) regulates the licensing of RES-Electricity production facilities.
- The ordinance on renewable energy sources (Official Gazette of Republic of Macedonia No.113/11 regulates: (i) facilities using RES for electricity production; (ii) the methodology for calculation of the necessary percentage for mixing the fossil and bio fuels for transport; (iii) the assessment of wind energy potential and issuing of the approvals for measuring wind energy potential; (iv) the registry of RES-Electricity facilities; (v) the terms and the conditions for issuing, transferring and withdrawing the guarantees of origin for the RES-Electricity; (vi) the terms and conditions for recognition of the guarantees of origin issued aboard; and (vii) the registry of issued guarantees of origin.
- Ordinances on feed-in tariffs (which do not include generation of electricity from geothermal energy).
- Electricity Market Rules (Official Gazette of Republic of Macedonia No.57/12, 168/12) issued by Energy Regulatory Commission of the Republic of Macedonia.
- The Energy Community Treaty, to which Macedonia is a contracting party.
- The Statutes of IRENA (International Renewable Energy Agency) have been signed by Macedonia, it being one of 75 founding members of this institution.
- The Law on Environment (Official Gazette of Republic of Macedonia No.53/05, 81/05, 79/06, 101/06, 109/06, 24/07, 159/08, 83/09, 1/10, 48/10, 124/10, 51/11, 123/12) regulates the terms and conditions and the procedures for issuing environmental permits.
- Law on Construction (Official Gazette of Republic of Macedonia No.130/09, 124/10, 18/11, 36/11, 49/11, 54/11, 13/12, 144/12) regulates the terms and conditions and the procedure for issuing the building permit.

- Law on Water (Official Gazette of Republic of Macedonia No.87/08, 6/09, 161/09, 83/10, 51/11, 44/12, 23/13) regulates the terms and conditions procedure for granting of the concession or Public Private Partnership for use of water.
- Law on Concessions and Public Private Partnership (Official Gazette of Republic of Macedonia No.6/12) regulates the general rules of the procedure for granting of concessions and Public Private Partnerships.
- Law on Mineral Resources (Official Gazette of Republic of Macedonia No.136/12, 25/13).
- Decision on commencing with the procedure for granting concessions for detailed geological surveys of mineral resources.
- Decision on commencing with procedure for granting concessions for exploitation of mineral resources.

Poland:

- Act of June 9, 2011, the Geological and Mining Law (Journal of Laws, No 163, item 981, as amended).
- Law of 7 July 1994 Building Law (Journal of Laws of 2013, item 1409, as amended).
- Act of 13 April 2007 on the prevention of environment damage and its repair (Journal of Laws of 2014 pos. 210).
- Act of 18 July 2001. Water Law (Journal of Laws 2012, item. 145).
- Act of 27 April 2001. The Environmental Protection Law (Journal of Laws of 2013, pos. 1232).
- Act of 3 October 2008 on the provision of information on the environment and its protection, public participation in environmental protection and environmental impact assessment (Journal of Laws of 2008, No 199, item 1227, as amended).
- Regulation of 6 February 2003 regarding occupational safety and health during construction works (Journal of Laws No. 47, item 401).
- Regulation of the Minister of Environment dated 24 July 2006 on conditions to be met when discharging sewage to waters or to the soil and on substances of particular adverse impact on the water environment (Journal of Laws 2006, no. 137, item 984, as amended).
- Regulation of the Minister of Labour and Social Policy 1997 on general provisions for safety and hygiene at work (Journal of Laws 2003, No 169, item 1650, as amended).
- Regulation of the Minister of Environment 4 October 2002 on requirements to be met by inland waters which provide habitats for fish living under natural conditions (Journal of Laws of 2002, No. 176, pos. 1455).
- Regulation of the Minister of the Environment (18 November 2014) for the placing sewage into the water or ground; and for substances that are particularly harmful to the aquatic environment (Journal of Laws from 2014, item 1800).

Serbia:

- Regulation on conditions and procedure of acquiring the status of privileged power producers (Fig. Gazette of RS, no. 8/2013)
- Regulation on Incentives for privileged electricity producers (Fig. Gazette of RS, no. 8/2013)
- Regulation on the method of calculation and the manner of distribution of funds collected from the fees for the encouragement of privileged power producers (Fig. Gazette of RS, no. 8/2013)
- Regulation on the amount of special fees for incentives in 2013 (Fig. Gazette of RS, no. 8/2013).

Slovakia:

- Act No. 364/2004 Coll. on water (Water act) - requirements related to geothermal water exploitation
- Government decision No. 269/2010 – incl. pollution standard, i.e. values after mixing discharged water with surface water, etc.
- Act No. 17/1992 Coll. on environment - regulates the terms and conditions and the procedures for issuing environmental permits.
- Act No. 24/2006 Coll. Assessment of environmental impact - EIA

- Act No. 525/2003 Coll. the state administration of the environment
- Decree of the RONI No. 184/2012 from 22nd of June 2012 - tariff level for different types of RES
- Act No. 50/1976 Coll. on construction - regulates the terms and conditions and the procedure for issuing the building permit.
- Act No. 309/2009 Coll. on promotion of RES - this act and its amendments help with the market integration for RES. It sets a mandatory purchase of electricity produced from RES, until the specified fix output, for different types of RES.
- Energy Policy of SR (2006) – use of RES
- Strategy of higher utilization of RES in Slovakia (2007)
- NREAP (2010) - mandatory national target for the Slovak Republic

Annex 2

Fiscal and financial conditions, constraints, sustainability, environmental issues vs. geothermal energy uses development in the GEOCOM countries – an overview

Collection and summary of essential descriptive information related to all particular GEOCOM states (prepared by appointed Experts)

HUNGARY

Environmental constraints:

In Hungary the most important environmental impacts related to geothermal energy utilization are: reservoir pressure decrease, pollution of fresh groundwater and the waterways on the surface, thermal effects and noise.

Hungarian geothermal reservoirs may be sedimentary, sandy or karstified limestone aquifers. Significant pressure decrease occurs mainly in porous reservoirs. Some fields have been exploited more than seventy years, thus the piezometric head of the reservoir had subsided almost 70 m in the Hajdúszoboszló field. The long-term geothermal operation also resulted up to 40 m drawdown in the Szentes geothermal field.

The freshwater aquifers are located above the geothermal reservoirs, thus the drilling operations can be hazardous. During normal drilling situations downhole drilling fluids are usually the greatest potential threat to environment. Well completion and stimulation operations using acid can be hazardous too. The greatest environmental hazard during drilling operation could be a well blow out. The most serious blow out of a geothermal well was in Fábiánsebestyén in 1985. The extreme saline brine water flowed to the small creek Kórógy lost all kinds of life. The noise level during the outburst reached 125 dB.

The salinity of the Hungarian brines is comparable to that of seawater. The water of the upper Pannonian aquifer contains mainly sodium or calcium carbonate, the brine in the lower Pannonian formations contains mainly sodium chloride. The environmental impacts of the released thermal waters can be serious. The total dissolved solid content usually between 1000-3000 mg/l, but there are some extreme examples too. The wells of Bükkszék spa produce more than 1m3/min of very saline water containing 24000 mg/l solved solids. In many cases there is no injection at all; the used geothermal brines are sent to surface creeks or rivers, and disposing to ponds are also very common. Some Hungarian thermal water contains toxic material (e.g. arsenic) and pathogenic organisms, bacteria, which if release in natural waterways harm the wildlife of these waters.

Most problems of the geothermal operations can be avoided by means of injection (injection). Despite the widespread use of geothermal energy resources, only a small amount of used geothermal water reinjected in Hungary.

Financial constraints

Hungary has favorable natural conditions for geothermal energy production, however the production and utilization only stagnating in recent time. The Hungarian geothermal sector has serious troubles due to the past years global economic recession and the weak Hungarian economy. The unstable legal environment relating the injection (required/not required) and the changeable energy policy were not favor to the development of Hungarian geothermal industry. The Hungarian specialist suggest to create „venture capital fund" in order to intensifying and stimulating financial investments. Injection wells should also be supported with financial and legal means.

Land concessions

In Hungary, as regards of geothermal energy „closed areas" are the parts of the earthcrust below the surface 2500 m. Through a concession contract entered into with domestic or foreign legal entities and natural persons the Minister may concede with definite period of time in closed areas the prospection, exploration and exploitation of geothermal energy. The right of prospection shall grant an exclusive right for the mining entrepreneur in the area of prospection, to submit a technological operation plan for the prospection of mineral raw material or to submit a technological operation plan. The planned period of prospection may not be longer than 4 years, within the period of concession. The period of prospection may be extended no more than two occasions, by half of the original period of prospection per occasion. Within the period of 1 year of the completion of the prospection the mining entrepreneur may initiate the designation of geothermic protective zone. If the holder of concession fails to commence the exploitation or the geothermal energy utilization he shall pay a compensation, fixed in the contract. If he fails to meet his obligation to pay compensation, the consession shall cease to exists.

In August 2013 the hungarian Minister for National Develoment issued calls for proposals for concessions. The potential geothermal investors can bid for exclusive mining concessions in 3 regions of Hungary: Jászberény, Ferencszállás and Kecskemét.

Sustainability issues in financial context

Sustainability issues in financial context: Locality of projects	Used geothermal heat energy (GJ)/exploited amount of water (m3)	Investment cost EU / GJ /yr	Running expenses EU / GJ /yr	Used geothermal heat energy (GJ)/ 1 M EU investment costs (EU)	Comments
Törökszentmiklós	0,104	96,6	4,27	0,23	Without injection. Using waste water heat of a public bath.
Szentlőrinc	0,037	156,6	2,9	0,07	Without injection. Significantly high public heat service fees.
Dombóvár (planned)	0,201	53,4	2,2	0,20	Without injection. High waterbase risk.
Csongrád	0,207	48,3	3,4	0,23	Without injection. Using waste water heat of a public bath.
Gyopáros	0,188	106,2	3,9	0,11	With 2 injection wells.
Makó	0,248	44,9	2,5	0,25	With 2 injection wells.

Water rights:

The water rights licensing procedure is the part of the Act LVII of 1995 on Water Management. There are four different types of license:

- conceptual water rights license(eligibility for planning)
- water rights license for installation (eligibility for constructing the facilities)
- water rights license for operation (eligibility for operating the facilities)
- water rights license for continuance (eligibility for further operating the facilities)

Government Decree No. 220/2004. (VII. 21.) Korm. on the protection of surface water quality.

Fees:

Water resource fee

This is a contribution to be paid to the central budget on all water utilisations. In the case of surface waters, for example in a water plant or regarding water used for irrigation, and in the case of underground waters, e.g. drinking water, bathing water, etc., the basis for the contribution is the water volume actually used as determined by measurement and the water fee (HUF/m3) which is identical in each water application, but because of the different multiplication factors, significant differences arise among the various utilisation approaches. From the aspect of harnessing geothermal water, there are only two important subsurface water categories: naturally one is geothermal water and the other is qualified medicinal water, because most of the latter are geothermal waters as well (t>=30 °C). The water fee depends on the type of water utilisation and water reserves, and it is modified by the multiplier 'g' subject to the water reserves management situation in the relevant area. The rates of the multiplier 'g' are the following: Energetic utilisation falls into the 'economic' 'other' category and hence has the highest multiplier

Consequently, the KHVM (Ministry of Environmental and Water Conservation Affairs) decree 43/1999 (XII. 26)KHVM which includes the table above, expressly gives preference to medication and considers energetic utilisation as the least desirable. No water reserves contribution is to be paid, if after energetic utilisation the spent geothermal water is returned to the underground aquifer. (And this is absolutely logical, because in this case no use (consumption) of the water reserves is involved). The rate of water fee is determined by the State Budget Act, and hence it changes from year to year. And it has indeed doubtlessly and dramatically increased in the last two years In the following diagram − when 1993 is regarded as the reference year – it is shown how the water fee, natural gas and electricity prices have grown, along with the annual inflation. It can be seen that the rise in water charges has slightly exceeded the inflation up to 2000, and then sharply climbed afterwards. Expressed in figures, this means that in two years the water fee grew by 79% nominally. Vis-à-vis energy supplied through conduits, the situation is even worse, as a result of which it can be stated that the competitiveness of harnessing geothermal energy has deteriorated as against the major competitor natural gas.

List of main legal acts and regulations:

Act XLVIII of 1993 on Mining (and its upgrades)

„The purpose of this Act is to regulate the mining of mineral raw materials, prospecting for and exploitation of geothermal energy, the establishment and operation of pipelines conveying hydrocarbon, and the activities related thereto, in harmony with the protection of life, health, security, the environment and property, and the management of mineral and geothermal Energy resources."

Sections 1., 3., 5., 8., 9., 14., 15., 20., 22., 22/B., 44., 45., 49. regulate the exploration, exploitation and the use of geothermal energy.

1.§: Effect of the Act
3. §: Right of the State
5. §: Prospecting and Exploitation that May Be Performed on the Basis of the License of the Authorities (Liberalized Activities)
8.§: Concession
9.§: Designation of Concession Areas
14., 15.§: Prospecting, Exploration and Exploitation
20.§: Mining Royalty
22.§: Licensing of Prospecting
44.§: Mine Supervision
45.§: Supervision by the Mine Supervision of the Raising to the Surface of Abyssal Waters

49.§: Definition of Terms
Regulation of land concession in the Act on Mining: the whole Part II of this act referring to the concession contracts. Sections: 8., 9., 10., 11., 12., 13., 14., 15., 18. and 19.

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Chapter II.: Responsibilities Related to Waters and Hydraulic Facilities
Chapter III.: Provisions Concerning Properties and the Operation of Properties
Chapter IV.: Public Utility Activities Performed with Waterworks (repealed)
Chapter V.: Water Resources Management
Chapter VI.: Control of and Emergency Defence Operations Against the Damage Caused by Water
Chapter VII.: Provisions for Real Properties in Connection With Waters and Hydraulic Facilities
Chapter VIII.: Competence of the Water Authorities
Chapter IX.: Water Management Associations
Chapter X.: Closing Provisions

Act LIII of 1995 on on the General Rules of Environmental Protection (and its upgrades)
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Chapter VII.: Remediation
Chapter VIII.: Permanent Environmental Damage
Chapter IX.: Registration System
Chapter X.: Legal Consequences
Chapter XI.: Miscellaneous, Closing and Transitional Provisions

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No water reserves fee is to be paid, if after energetic utilisation the spent geothermal water is returned to the underground aquifer
Major Hungarian legislation concerning groundwater

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ITALY

<u>Financial constraints</u> (on capital investments, flow of capital and other)

- Lack of mining risk coverage: the drilling phase is capital intensive and statistically every 4 wells, 1 is unproductive

- Need for closer links between national and regional incentives, concerning geothermal power production and to promote direct geothermal heat uses

- Need of more financial support tools for R&D projects, in order to develop new non-conventional geothermal systems

- Lack of financial support tools for investments in geothermal projects

- The new feed-in-tariff system regulates incentives for electricity generation from RES (including geothermal) in new plants (into operation after 1/1/2013) and it includes additional incentives (and direct access to incentives) for power plants using advanced technologies, as below:

Base FEED-IN TARIFF	
Power < 1MW	135 euro/MWh
Power from 1 MW to 20 MW	99 euro/MWh
Power > 20 MW	85 euro/MWh
ADDITIONAL AWARD-INCENTIVES	
For the first 10 MW each new area	30 euro/MWh
Total injection of geothermal fluids and zero emission plants	30 euro/MWh
High enthalpy plants removing 95% of H2S and Hg	15 euro/MWh
"Pilot Plants" with given features	Up to 200 euro/MWh (non-cumulative with the above tariffs)

Plants with P>20MWe: incentives are awarded through participation in lowest bid auction procedures. But according to trade associations, the lowest bid auction discipline is difficult to apply to geothermal sector because of the required capital intensive investments, the existence of an high mining risk and authorization procedures long lasting and complex.

- Innovative plants may gain access to a simplified procedure to benefit of these incentives.

- As for geothermal DHs, except for possible regional incentives, most of financial support measures are for end-users, national financial support for investments (only 20% tax credit on investment) is limited and inadequate. Regional incentives change depending on the region: some region may support investments in new plants (through guarantee founds, co-financing, long term agreement with ESCOs, etc.), some other do not.

- White certificates are not cumulative with other public support measures

- Thermal feed-in-tariff is only for small size RES heat production plants (< 1MW)

- Technological-economic constraints concerning geothermal technologies: these technologies (especially for heat and cool uses) would not yet survive in the current market if not adequately incentivised, then currently the great environmental benefits offered by these technologies does not go hand in hand with those economic.

Environmental constraints/considerations[1]:

- Disposal of geothermal fluids: spent geothermal fluids (without the gaseous component) can be injected into their originating geothermal reservoir, or disposed in other manner (i.e. in surface water bodies), after being adequately treated in order to minimize their environmental impact. The environmental and hydrogeological impact of disposal must be always constantly monitored.

- Injection of geothermal fluids: injection is incentivised at national level (see incentives above) and for a sustainable use of the resource, it is the only method currently applied to dispose spent geothermal fluids from geothermal power plants. Moreover the injection of geothermal fluids prevents subsidence phenomena.

- Air pollution emission of geothermal power plants[2]: parameters covered by the national legislation represent only partially the current emission framework (H_2S, Hg, As), also characterized by unregulated pollutants (e.g. Sb, Se, NH3, CH4, and CO) and for which emission limits are not established. Environmental monitoring of these substances only depends on possible regional level limits. Additionally, national legislation is referred to hourly average (calculated on monthly basis), implying a continuous monitoring of emissions, which is still technically impossible to implement on geothermal power plants. Moreover Hg and As national limits are only referred to dissolved salts in drift (1% of total), since an official and reliable technique for this sampling design does not yet exist.

- Wells deeper than 30 m must be notified to the national Institute for the Environmental Protection and Research (ISPRA)

- Geothermal projects > 1MW (and with wells deeper than 400 m) are subordinated to EIA screening (procedure duration 150-330 days) and possibly to EIA (procedure duration 90 days). EIA screening has to be delivered to the environmental authority when applying for exploration and exploitation permits to regional authority (or other delegated authorities). EIA screening is mandatory also for surface installations, but specific limits and rules change by region.

Land concessions:

- Geothermal resource ownership: national and local related geothermal resources belong to “mines” category, and according to the art. 826 of the Civil Code, they are classified as goods property of the Italian State (national related resources) and of the regions (local related resources), available with a concession issued by a delegated public. Resources for *small local utilizations* are considered underground resources, belonging to groundwater category, property of the Italian State (as before).

[1] The website of the Regional Agency for the Environmental Protection of Tuscany (ARPAT) has a section concerning environmental issues related to the use of geothermal energy in Tuscan power plants and to their relative environmental pressures in Tuscan geothermal areas (e.g. monitoring results, environmental studies, etc.). Available (in Italian) at: http://www.arpat.toscana.it/temi-ambientali/aria/aree-geotermiche

[2] For further details on the reference legislation and on constraints linked to its inadequacies, see the article (in Italian only)of ARPAT the at: http://www.arpat.toscana.it/notizie/arpatnews/2013/150-13/150-13-centrali-geotermiche-la-normativa-di-riferimento-per-i-controlli-arpat/

- Geothermal projects < 2 MWt, with wells < 400 m, are called "*small local utilizations*" and require a "simplified" procedure known as "*Unique Authorization*" and authorities in charge for the administrative functions are Italian Regions or delegated authorities (e.g. provinces or municipalities).

  Other geothermal projects require an *exploration permit* and an *exploitation permit*, both issued and managed by Italian Regions or delegated authorities. *Exploration permit*: applicant must demonstrate adequate technical and financial capability (e.g. bank guarantee) and a work plan, as well as EIA (if required). Maximum surface of each permit is 300 km2 (1000 km2 at regional level and 5000 km2 at national level), time required to approve a demand should last 240 days but it may be longer (mostly for environmental assessment) and it costs up to 325 €/km^2·year. *Exploitation permit*: it is a mining lease lasting 30 years and it allows to perform all activities for the exploitation of geothermal resources on a specific area and it requires a work plan and a bank guarantee or insurance for environmental recovery, as well as EIA (if required). Maximum annual lease for exploitation is 650 €/km^2. Moreover companies have to pay compensations for each KWh produced (0,13 cent€/KWh to municipalities and 0,195 cent€/KWh to regions) and regions (e.g. Tuscany) may apply additional fees through voluntary agreements for the exploitation of geothermal resources in power plants, reinvesting the revenues for the development of geothermal areas.
- Total time needed to obtain all permits (EIA included) is usually 38 months.

- For pilot plants experimentation and for offshore geothermal resources, the authority in charge for issuing permits is the Ministry of economic development in agreement with the Ministry of Environment.

- Compulsory purchase procedure is sometimes necessary for surface works. In this regard bureaucratic processes may slow down geothermal projects.

- In low enthalpy resources uses, ministerial procedural guidelines on technical management aspects are needed, as well as a monitoring system for the uses of the resource, since dynamic nature of local alterations is not considered

- **Water rights:**

- Regional authorities may decide to enforce mining lease procedure for the reuse of spent geothermal fluids or gases from geothermal plants.

- Injection of geothermal fluids is a way to dispose used geothermal fluids and it is not properly mandatory. It is preferred to other disposal ways (and actually it is the only way used to dispose spent geothermal fluids), since it can ensure a long term utilization of the geothermal reservoir, it is incentivised (see above) and it is an alternative to expensive treatment processes.

General analysis of economic viability and cost-effectiveness of geothermal projects in relation to avoidance/reduction of CO_2 emissions (carbon footprint reduction)

Against higher required investment costs, if compared with other RESs, geothermal energy guarantees a continuous production through the year, with a capacity factor near to 1. As a matter of fact 10 MW of geothermal installed capacity are equivalent to the production of 40-50 wind power MW.

According to an assessment document of the National Agency for new technologies, energy and the sustainable economic development (ENEA)[3], on GHG emission reduction, geothermal energy is the second most affordable technology for the reduction of CO_2 emissions, after refuse-derived biogas.
These assumptions are made considering that CO_2 emissions from geothermal power plants are natural and conventionally not included in GHG emission quotas allocated to EU countries, hence geothermal power plants contribute to achieve GHG emission reduction 2020 EU objectives. However, contrary to most of geothermal fields around the world, Italian geothermal fields have high contents of carbonate rocks, which in 2010 resulted in a real average emission from Italian geothermal power plants equal to 360 g CO_2/kWh_e.
As for geothermal heat pumps, air-water heat pumps have lower costs than a geothermal, but they imply higher environmental impact and lower productivity.
No more available data/information were found about this issue.

Sustainability issues in a financial context

In order to prevent the degradation of environmental quality of surface and ground water, the disposal of exhausted geothermal fluids without being properly treated (with expensive techniques) is not allowed since 1976. Hence the injection of spent geothermal fluids (previously separated from the gaseous fraction) was successfully tested, as it also resulted in an improvement of the pressure and production of geothermal reservoirs, making geothermal energy exploitation more sustainable for long-term uses. Indeed the charging time of a geothermal reservoir use to be rather slow, since the average rock permeability is approximately 10^{-14} m^2.

However, high silicates contents and physical chemical characteristics of geothermal fluids may cause fouling of injection wells. This could be solved reducing silicate contents in spent geothermal fluids before the injection.

Spent geothermal fluids of water-dominated reservoirs may also be used for drinking purposes, after being adequately treated (through distillation), in order to comply with current provisions concerning drinking waters.

Concerning injection wells, the current practice of using old production wells for the injection is not always the best and the planning of injection during the geothermal exploitation initial phase is increasingly considered as the best solution.

List of main legal acts and regulations:

- D.M. 06-07- 2012 (Ministry of Economic Development) “Implementation of the art.24 of the legislative decree 3 march 2011 n.28, containing incentives for the production of electricity from renewable sources not-photovoltaic”;

- Direttiva 01-07-2011 (Ministry of Economic Development) “Directive for the first implementation of the modifications introduced by the Legislative Decree 28/2011 to the Legislative Decree 22/2010 for the reorganization of the legislation on exploration and exploitation of geothermal resources for matters pertaining to the Ministry of Economic Development”;

[3] ENEA (2010). Quadro Strategico Nazionale 2007-2013: VALUTAZIONE DELL’IMPATTO POTENZIALE DEI PROGRAMMI OPERATIVI FESR SULLA RIDUZIONE DELLE EMISSIONI DI GAS SERRA. Available at: http://www.solartech-energy.it/download/2010/enea-rapporto-gas-serra-2010.pdf

- D. Lgs. 03-03-2011 n.28 "Implementation of the directive 2009/28/CE on the promotion of the use of energy form renewable sources, containing modification and following abrogation of the directives 2001/77/CE and 2003/30/CE";
- D. Lgs 03-04-2006 n.152 "Environmental regulations"
- D. Lgs. 29-12-2003 n.387 "Implementation of the directive 2001/77/CE concerning the promotion of power generation from renewable energy sources within the national electricity market"
- D. Lgs. 11-02-2010 n.22 "Reorganization of the legislation on exploration and exploitation of geothermal resources, according to the art. 27, clause 28, of the law July 23 2009, n.99";
- D.P.R. 08-08-1994 n. 485 "Regulations governing the procedures of issuing an exploration permit and mining lease of national interest geothermal resources";
- D.P.R. 27-05-1991 n.395 "Approval of the implementing law of the December 9 1986 n.896 law, concerning regulations for the exploration and exploitation of geothermal resources";
- Article 826 of the Italian Civil Code, concerning properties of the State, Provinces and Municipalities
- R.D. 11-12-1933 n.1775 "Law on legal provisions on water and electrical systems"
- R.D. 29-07-1927 n.1443 "Legislative rules framework to govern the mines exploration and exploitation into the kingdom".
- Agreement Protocol 20-12-2007 "General Agreement on Geothermal Energy" exploitation in Tuscan power plants
- 20-04-2009 "Voluntary agreement for the implementation of the Agreement Protocol of 20-12-2007 known as General Agreement on Geothermal Energy"
- Tuscany Region Law 24-02-2005 n.39 "Provisions concerning Energy"
- Tuscany Region Law 12-02-2010 n.10 "Regulations concerning Strategic Environmental Assessment (VAS), Environmental Impact Assessment (VIA) and environmental effects assessment"

MACEDONIA

Financial constraints

There are no specific financial constraints; on the contrary, Macedonia offers very favorable conditions for investments. On the other side there are no any devoted financial incentives for investment in geothermal heat plants/systems, neither power generating facilities.

If geothermal power plant is to be connected to the grid the common laws apply since there are no preferential tariffs for the energy of geothermal origin.

Subject to the provisions of the Law on Energy, for the purpose of realization of the Strategy for use of RES, the mechanism of financial support is established on the grounds of financial means collected from: (i) the state budget; (ii) grants, donations, sponsorships; (iii) credits; and (iv) state aid pursuant with the law. The Strategy for use of RES does not currently recommend any other incentive/s besides the feed-in tariffs and guarantees of origin, which apply solely to power generation.

Environmental constraints

There are no environmental constraints. As for any other foreseen investment (plant, system, building) environmental permit preceded with elaborate for assessment of the influences to the environment to which the Law on Environment applies.

There are no realized geothermal projects recently (when the Law on Environment is effective), but there are no special provisions foreseen for geothermal subsurface and surface installations.

There is no obligation on geothermal fluids injection.

Land concessions

If the land where the geothermal activities are foreseen is in private property, it is not necessary to obtain concession for the land use. The procedure involves obtaining permit for the intended activities which should be in accordance to the land category (industrial, building, agricultural or else), if not than procedure for makeover of the land category must be initiated.
The land concessions are granted if the land is in the property of the state i.e. municipality according to the Law on Concessions and Public Private Partnership, Law on Building Land (Official Gazette of RM, no.17/2011 and 53/2011), and the Building program of the Municipality.

Water rights, licensing system for geothermal exploration, exploitation

The procedure for granting a right (concession) to explore or exploit geothermal resources in the RM is organized in the form of a tender procedure and is governed by the Act on Concessions and PPPs and Decision on commencing with the procedure for granting concessions for detailed geological surveys of mineral resources or Decision on commencing with the procedure for granting concessions for exploitation of mineral resources. The concession types, and the terms and conditions are regulated by the Law on Mineral Resources and the Law on Waters.
For the use of water in geothermal exploitation, concession for water use must be obtained.

The Law on Water provides that the concession for water use shall be implemented in the form of a public tender or as a formal request.

The tender procedure can be in the form of a public call initiated with a formal proposal from the Minister of Economy. The proposal for granting the concession must emanate from the Ministry of Economy and the decision to commence the procedure and the decision to grant the concession (for exploration or exploitation) must be passed by the Government of Macedonia.

In addition prior to conclusion of the Concession Agreement, the permit for water use must be also obtained by the Ministry of Environment.

Main laws and regulations that regulate the right of exploration of geothermal site are:

- Law on Mineral Resources (Official Gazette of Republic of Macedonia No.136/12, 25/13),
- Law on Concessions and Public Private Partnership (Official Gazette of Republic of Macedonia No.6/12) regulates the general rules of the procedure for granting of concessions and Public Private Partnerships,
- Decision on commencing with the procedure for granting concessions for detailed geological surveys of mineral resources.

In case of permits or licenses' systems for various kinds of geothermal drillings (exploration, exploitation ones) in Macedonia, relevant permits and concessions are granted by the government and several ministries are involved in various ways in the procedures. The system is rather formalized and multi-staged (as described in details in Annex 2).

Permission to conduct detailed geological surveys:

The Article 10 of the Law on Mineral Resources stipulates the right to perform detailed geological surveys for geothermal water to be achieved by obtaining a license for conducting detailed geological surveys. The license for carrying out detailed geological surveys is issued by the Department for Mineral Resources (Ministry of Economy of RM) which is responsible for conducting the activities from the area of mineral resources.

Article 12 of the Law on Mineral Resources, regulates the Priority right for granting a license for conducting detailed geological survey in a case of having multiple supplicants requiring a license for the same area, where the priority right to grant the license for conducting a detailed geological survey of geothermal water, has the supplicant who first submitted the request.

The requests for granting a license for conducting detailed geological surveys are published in the Official Gazette of the Republic of Macedonia, and if within thirty days from the publication, the owner of the area appears as a supplicant for granting license, than the owner has priority in receiving the permit.

Article 14 of the Law on Mineral Resources regulates the issue on the area for conducting detailed geological surveys, where it is stipulated that the permit for conducting detailed geological surveys is given for exactly determined area, more precisely, within the second paragraph, item 6, it is stated that the license for conducting detailed geological surveys, is given for a space not bigger than 2 km^2 for mineral and geothermal water and potable groundwater, where the smallest distance in a radius of already granted concession for exploitation of these minerals or issued permit for conducting detailed geological surveys, should not be less than 2 km. Also Article 14 stipulates that a license can be granted for a period of time according to the project submitted for conducting detailed geological surveys, but not longer than eight years.

In the Article 21 of the Law on Mineral Resources the ownership of the results of the detailed geological surveys is regulated, where it is indicated that the results obtained by carrying out detailed geological surveys are owned by the holder of the license for detailed geological survey, and that the holder has the right to transfer them to another person. The holder of the results, obtained from conducted detailed geological surveys, has right for compensation of the costs incurred in the performance of the survey from the bidder who has been chosen as concessioner on the public announcement, by the grantor (the Government of the Republic of Macedonia). The holder of the license for conducting detailed geological surveys for mineral resources pays single fee for the exploration area.

The Government, on the proposal of the Minister of Economy, adopts a schedule that sets the fees for conducting detailed geological survey and exploration concessions on resources depending on the type, quantity and quality of mineral resources.

The procedure for granting a right (concession) to explore or exploit geothermal resources in the RM is organized in the form of a tender procedure and is governed by the Act on Concessions and PPPs and Decision on commencing with the procedure for granting concessions for detailed geological surveys of mineral resources or Decision on commencing with the procedure for granting concessions for exploitation of mineral resources. The concession types, and the terms and conditions are regulated by the Law on Mineral Resources and the Law on Waters.
The tender procedure can be in the form of a public call initiated with a formal proposal from the Minister of Economy. The proposal for granting the concession must emanate from the Ministry of Economy and the decision to commence the procedure and the decision to grant the concession (for exploration or exploitation) must be passed by the Government of Macedonia.

Laws and regulations for exploitation:

Laws and regulations related to exploitation of geothermal site are:

- Law on Mineral Resources (Official Gazette of Republic of Macedonia No.136/12, 25/13);
- Law on Water (Official Gazette of Republic of Macedonia No.87/08, 6/09, 161/09, 83/10, 51/11, 44/12, 23/13) regulates the terms and conditions procedure for granting of the concession or Public Private Partnership for use of water;
- Law on Concessions and Public Private Partnership (Official Gazette of Republic of Macedonia No.6/12) regulates the general rules of the procedure for granting of concessions and Public Private Partnerships;
- Decision on commencing with the procedure for granting concessions for exploitation of mineral resources.

The procedure for granting a right (concession) to exploit natural resources in the Republic of Macedonia is organized in the form of a tender procedure and is governed by the Act on Concessions and PPPs, unless provided otherwise by a special law referring to the specific natural resource. The concession types, and the terms and conditions are regulated by special laws referring to the specific natural resource, which is the subject of the concession. Special laws referring to natural resources also provide detailed rules on which authority may issue the initial proposal commencing the procedure for granting the concession and the procedure for obtaining the necessary consents and opinions from the relevant public authorities.

The Waters Act provides that the concession for water use shall be granted under the public tender or under the formal request. The tender procedure can be in the form of a public call initiated with a formal proposal from the competent Ministry of Environment and Civil Planning under the prior consent of the other competent Ministries for: agriculture, economy, transport and communications, defense, interior and culture and prior consent of the State institution for monuments protection. The decision to grant the concession must be passed by the Government of Macedonia and published in the Official Gazette of the Republic of Macedonia.

The formal request for water use may be submitted by public companies, public institutions, trade companies established by the Republic of Macedonia and the companies where the state has direct or indirect control on the ownership (i.e. companies where the state owns a significant part of the capital of the company, has majority shareholder's votes and where the state appoints half of the members of the management or the supervisory board or the management bodies of the company) and other legal entities performing public functions, whereby the concession will be granted without a public call for tenders. The formal proposal (under the mentioned formal request) for granting the water concession must emanate from the competent Ministry of Environment and Civil Planning and the decision to commence the procedure and the decision to grant the water concession must be passed by the Government of Macedonia.

In addition prior to the conclusion of the Concession Agreement, the permit for water use must also be obtained by the Ministry of Environment and Civil Planning.

Concessions for exploitation of geothermal resource:
In Article 23 of the Law on Mineral Resources which regulates the concession for exploitation of mineral resources, it is anticipated that the right to carry out the exploitation of mineral resources - geothermal waters, can be achieved by obtaining a concession for exploitation of mineral resources. Concession for exploitation of mineral resources - geothermal water, assigns the Government, i.e. the grantor. Any natural or legal person may apply as a concessioner, but also, foreign entity with registered subsidiary in the Central Registry of the Republic of Macedonia and meeting the requirements under the Law on Energy, may appear as a concessioner.

In Article 24 of the same law it is foreseen that with the concession, the grantor as owner transfers the mineral resources to the concessioner, for their exploitation in concrete area and in determined time frame, at the concessioner's expense and risk.

The Article 25 stipulates that concession for exploitation of mineral resources shall be granted on concrete land area (not more than the space within the exploration permit), and on the basis of the presented study for justification of the requested concession i.e. concession project and elaboration for the conducted detailed geological surveys. The land area covered by the land area for concession of exploitation can be in public and private property. And, the exploitation of mineral resources is done on the concerned land area defined by the main and the additional mining project for the exploitation of mineral resources.

The Article 26 of the Law on Mineral Resources stipulates that the period of concession for exploitation of mineral sources is up to 30 years with possible extension for another period until exhaustion of mineral sources, because of which, the concession has been awarded, but not longer than 30 years.

In Article 27 which regulates the ways of granting concessions it is foreseen that granting the concession for exploitation of mineral resources can be made on the basis of open competition or at the request of interested persons.

In Article 34 of this Law it is foreseen that concession for exploitation of geothermal water can be transferred wholly or partly, by adopting decision of the grantor. Within the decision can be predicted transfer of rights to the concession in favor of the lenders as a mean of ensuring their claim to the concessioner, but the subject of the concession for exploitation should not be given under lease. With the transfer of the concession, the concessioner acquires rights and responsibilities resulting from the permits and approvals from competent authorities.

In addition to the Law of Mineral Resources it is foreseen that the exploitation of mineral resources and performing mining activities, can start when the concessioner will obtain permit to exploit mineral sources. This permit is issued by the Minister of Economy and it is valid in a time frame not longer than the period of validity of the concession for exploitation.

Concessionaire for the exploitation of geothermal water is obliged to pay:
a) annual fee for using the land area allocated to the concession for exploitation, and
b) compensation for the exploitation of mineral resources.

The Government, on the proposal of the Minister of Economy, adopts a schedule that sets the fees for conducting detailed geological survey and exploration concessions on resources depending on the type, quantity and quality of mineral resources.

The procedure for granting a right (concession) to explore or exploit geothermal resources in the Republic of Macedonia is organized in the form of a tender procedure and is governed by the Act on Concessions and PPPs and Decision on commencing with the procedure for granting concessions for detailed geological surveys of mineral resources or Decision on commencing with the procedure for granting concessions for exploitation of mineral resources. The concession types, and the terms and conditions are regulated by the Law on Mineral Resources and the Law on Waters.

For the use of water in geothermal exploitation, concession for water use must be obtained.
The Law on Water provides that the concession for water use shall be implemented in the form of a public tender or as a formal request.

The tender procedure can be in the form of a public call initiated with a formal proposal from the Minister of Economy. The proposal for granting the concession must emanate from the Ministry of Economy and the

decision to commence the procedure and the decision to grant the concession (for exploration or exploitation) must be passed by the Government of Macedonia.
In addition prior to conclusion of the Concession Agreement, the permit for water use must be also obtained by the Ministry of Environment.

General analysis of economic viability and cost-effectiveness of geothermal projects in relation to avoidance/reduction of CO_2 emissions (carbon footprint reduction)

In Macedonia the existing geothermal resources are of low-temperature nature, therefore they are used mainly in balneology and heating of greenhouses and some buildings. The exploitation systems are old (more than 30-40 years) – when designed and realized no attention was paid to the CO_2 emissions avoidance. Even today, this data is not regularly calculated and taken into consideration.

Sustainability issues in a financial context

In Macedonia there is no obligation to inject the used geothermal water back to the reservoir; neither attention is paid to the long-term sustainability of the geothermal resource.

List of main legal acts and regulations

- The Energy Law (Official Gazette of Republic of Macedonia No.16/11, 136/11, 79/13) is the central energy regulatory act.
- Strategy for the development of the energy sector in the Republic of Macedonia until 2030 (Official Gazette of Republic of Macedonia No.61/10). According to the Strategy, the participation of RES in total energy use in Macedonia presented as a percentage will increase from thirteen point eight per cent (13.8%) in the year 2005 to twenty one per cent (21%) in the year 2020.
- Strategy for use of RES in the Republic of Macedonia until 2020 (Official Gazette of Republic of Macedonia No.125/10).
- The ordinance on the licenses for performance of energy activities (Official Gazette of Republic of Macedonia No.143/11) regulates the licensing of RES-Electricity production facilities.
- The ordinance on renewable energy sources (Official Gazette of Republic of Macedonia No.113/11 regulates: (i) facilities using RES for electricity production; (ii) the methodology for calculation of the necessary percentage for mixing the fossil and bio fuels for transport; (iii) the assessment of wind energy potential and issuing of the approvals for measuring wind energy potential; (iv) the registry of RES-Electricity facilities; (v) the terms and the conditions for issuing, transferring and withdrawing the guarantees of origin for the RES-Electricity; (vi) the terms and conditions for recognition of the guarantees of origin issued aboard; and (vii) the registry of issued guarantees of origin. The principal aims of the RES Ordinance are: (i) to increase the use of RES in the country; (ii) to create substitutes for the use of fossil fuels and decreasing of the amount of imported energy in the long-term; (iii) to encourage entrepreneurship in the sector and establishment of new jobs; (iv) to encourage new technologies; and (v) to ensure a sustainable supply of electricity while protecting the environment.
- Ordinances on feed-in tariffs which do not include generation of electricity from geothermal energy.
- Electricity Market Rules (Official Gazette of Republic of Macedonia No.57/12, 168/12) issued by Energy Regulatory Commission of the Republic of Macedonia.
- The Energy Community Treaty, to which Macedonia is a contracting party.
- The Statutes of IRENA (International Renewable Energy Agency) have been signed by Macedonia, it being one of 75 founding members of this institution.

- The Law on Environment (Official Gazette of Republic of Macedonia No.53/05, 81/05, 79/06, 101/06, 109/06, 24/07, 159/08, 83/09, 1/10, 48/10, 124/10, 51/11, 123/12) regulates the terms and conditions and the procedures for issuing environmental permits.
- Law on Construction (Official Gazette of Republic of Macedonia No.130/09, 124/10, 18/11, 36/11, 49/11, 54/11, 13/12, 144/12) regulates the terms and conditions and the procedure for issuing the building permit.
- Law on Water (Official Gazette of Republic of Macedonia No.87/08, 6/09, 161/09, 83/10, 51/11, 44/12, 23/13) regulates the terms and conditions procedure for granting of the concession or Public Private Partnership for use of water.
- Law on Concessions and Public Private Partnership (Official Gazette of Republic of Macedonia No.6/12) regulates the general rules of the procedure for granting of concessions and Public Private Partnerships.
- Law on Mineral Resources (Official Gazette of Republic of Macedonia No.136/12, 25/13)
- Decision on commencing with the procedure for granting concessions for detailed geological surveys of mineral resources
- Decision on commencing with the procedure for granting concessions for exploitation of mineral resources

POLAND

Financial constraints

In this group missing are, among other: start-up subsidies for new production plants, financial subsidies in forms of feed-in-tariffs and certificates of origin (for heat); Financial measures dedicated for drilling and operation of geothermal wells: no subsidies for drilling, no geological risk guarantee fund.

Environmental constraints

Injection of spent geothermal water is not obligatory and generally not required as a rule by the legislation (geological&mining law, water law) but it is considered and recommended on case by case basis. In particular cases the operators have to apply this technology, specially if water has high TDS content, since other environmental and water law regulations and requirements do not allow to dispose high TDS water into surface water streams). Also the operators (specially in case of geothermal heating plants) apply or tend to introduce injection as a tool to maintain long term sustainable production from the geothermal reservoir – necessary as a basis for safe and stable development and management. However, in such situation the investment costs are significantly higher and injection wells are sometimes designed and drilled not at the initial stage of the project but later (when the installation is already bringing some incomes).

Land concessions, drilling permits, licenses

Permit for drilling of geothermal wells and license for exploitation of geothermal waters are issued by the Marshal of the Voivodeship (regional administration level). Exploration permit – requires a decision approving the geological works project (validity period depends on the complexity of the project and work schedule). EIA is required when drilling is located in: the water intake protection zones, protection areas of inland water reservoirs, the areas covered by forms of nature protection. EIA screening is also needed for drilling deeper than 5000 m. Consent for the extraction of geothermal waters is issued in the form of a license (concession) for a period of up to 50 years. In the license specified are: mine-field boundary and mining area boundary as an area where operator can extract geothermal water, so the range of the cone of depression shouldn't go beyond these boundaries. Also the obtain a license for exploitation the waters requires EIA decision. Application for a building permit shall include: permit drilling and water discharge (issued by the competent Regional Head Office For Water Management) and other construction permit (issued by the Building Authority in the affected area/ district/ province).

One shall specially point out these favorable conditions for issuing the permits and licenses for geothermal drillings put into force by new geological and mining law in 2012. It simplified some procedures by, among others, introducing a single system of licensing (for exploitation wells) and transfer it to the competences of regional administration (before the licenses were obligatory both for exploration and exploitation wells and issued by the minister of environment). Other provisions facilitating geothermally-oriented activities include:

- exemption from royalties for geothermal water exploitation,
- exemption from fees for the geological information used for project purposes,
- reduction of fees for the use of geological information in order to exploit geothermal water (up to 1% of its value to 31/12/2020, then 5%),

- cancellation of licenses for exploration and prospecting of geothermal water – just geological works project to be approved by the regional administration (no need to prove the funds to operate, no license fee, no contract for mining operation /only the stamp duty for a decision/),
- shortening the exploitation license procedures by a significant reduction of the duties of cooperation with other bodies while issuing the decision on concession.

Polish system presents a good practice case how to optimise the procedures related to drilling geothermal wells.

Water rights

The permission of the Water Law in geothermal exploitation apply to discharging spent geothermal waters into surface waters. Water permit is required for the discharge of used water to surface watercourse. Such water has to meet the relevant requirements in respect to temperature and physical-chemical composition. These requirements are introduced by the Regulation of the Minister of the Environment (18 November 2014) for the placing sewage into the water or ground; and for substances that are particularly harmful to the aquatic environment (Journal of Laws from 2014, item 1800).
Each member of the European Union according to the Water Framework Directive was obliged to achieve the good status of water quality and ecological status in separate surface water bodies. Therefore, the quality of water discharged to surface receivers cannot affect the conditions of water management in the catchment areas defined by the Water Management Plans. These plans are reviewed at the national level every six years, in accordance with the criteria laid down in Art. 4 WFD (*Environmental Objectives of WFD).* Good status of water quality should be achieved by 2015. In appropriate cases, where the interest of socio-economic development takes precedence, temporary derogations to separate sections of the river are allowed. In these case good condition should be achieved in the shortest possible time, in subsequent planning periods (2021, 2027) or as soon as possible after this year.

Sustainability issues in a financial context

Injection of spent geothermal water is not obligatory and generally not required as a rule by the legislation (geological&mining law, water law) but it is considered and recommended on case by case basis. In particular cases the operators have to apply this technology, specially if water has high TDS content, since other environmental and water law regulations and requirements do not allow to dispose high TDS water into surface water streams). Also the operators (specially in case of geothermal heating plants) apply or tend to introduce injection as a tool to maintain long term sustainable production from the geothermal reservoir – necessary as a basis for safe and stable development and management. However, in such situation the investment costs are significantly higher and injection wells are sometimes designed and drilled not at the initial stage of the project but later (when the installation is already bringing some incomes).

List of main legal acts and regulations

- Act of June 9, 2011, the Geological and Mining Law (Journal of Laws, No 163, item 981, as amended).
- Law of 7 July 1994 Building Law (Journal of Laws of 2013, item 1409, as amended).
- Act of 13 April 2007 on the prevention of environment damage and its repair (Journal of Laws of 2014 pos. 210).
- Act of 18 July 2001. Water Law (Journal of Laws 2012, item. 145).
- Act of 27 April 2001. The Environmental Protection Law (Journal of Laws of 2013, pos. 1232).

- Act of 3 October 2008 on the provision of information on the environment and its protection, public participation in environmental protection and environmental impact assessment (Journal of Laws of 2008, No 199, item 1227, as amended).
- Regulation of 6 February 2003 regarding occupational safety and health during construction works (Journal of Laws No. 47, item 401).
- Regulation of the Minister of Environment dated 24 July 2006 on conditions to be met when discharging sewage to waters or to the soil and on substances of particular adverse impact on the water environment (Journal of Laws 2006, no. 137, item 984, as amended).
- Regulation of the Minister of Labour and Social Policy 1997 on general provisions for safety and hygiene at work (Journal of Laws 2003, No 169, item 1650, as amended).
- Regulation of the Minister of Environment 4 October 2002 on requirements to be met by inland waters which provide habitats for fish living under natural conditions (Journal of Laws of 2002, No. 176, pos. 1455).
- Regulation of the Minister of the Environment (18 November 2014) for the placing sewage into the water or ground; and for substances that are particularly harmful to the aquatic environment (Journal of Laws from 2014, item 1800).

SERBIA

Financial Limitations

There are no specific financial restrictions; on the contrary, Serbia offers rather favourable conditions for investments. On the other hand, there are no foreseen financial incentives defined in the budget for investments in geothermal heat plants (systems) or for thermal energy facilities.
For the time being, the conditions for the connecting geothermal power plants to the grid do not exist, because the current tariff system failed to define the method for determining the production price for kWh.
In line with the Law on Energy and in order to implement the Strategy on Using Renewable Energy Sources (RES), the financial support mechanism has been defined based on financial sources from: (1) the state budget, (2) donations, sponsorships, (3) loans and (4) state support in accordance with the Law. No other incentives are foreseen by the Strategy on RES Use.

Environmental Restrictions

There are no limitations in view of the environment. Similarly to any other planned investment (plant, equipment, infrastructure.....) it is preceded by the preparation of the environmental impact assessment in accordance with the applicable Law on Environmental Protection. There are no special stipulations for geothermal projects implemented recently (regardless of the effective Law on Environmental Protection), which foresee surface geothermal installations.
Mandatory injection of used geothermal water fails to exist.

Land Concessions

If the land on which geothermal energy exploration and use activities have been foreseen is a private property, there is no need to acquire concession for the use of the land. The procedure implies the acquisition of permit for the planned activities, which should be compliant with the category of the land (industrial, building, agricultural or other).
Land concessions are granted in cases when the land is a state, or municipal property in line with the Law on Concessions and Public-Private Partnerships and the Law on Building Land.

Geothermal Water Exploitation Rights

The procedure for acquiring the right (concession) to explore or exploit geothermal resources in Serbia is organised as a tender procedure and is regulated by the Law on Concessions and Public-Private Partnerships and the Decision on initiating the procedure for granting concession for detailed geological exploration of mineral resources or granting concession for the exploration of mineral resources. The types and conditions of concessions are set by the Law on Mineral Resources and the Law on Water.
For using geothermal water under exploitation, an exploitation permit should be obtained based on the Study on Reserves, which is reviewed each 5 years.
The Law on Water foresees that the approval for the use of geothermal waters is to be awarded within a public tender or as a formal request.

The tender procedure may be in a form of public call initiated by the formal proposal of the minister of economy. The proposal for awarding the permit should come from the Ministry of Economy based on the decision on initiating the procedure and the decision on awarding concesion for exploring (or exploiting) aims and is to be adopted by the Government of Serbia. Prior to concluding a concession agreement, a geothermal water exploitation permit should be obtained from the ministry in charge of environmental protection.
A geothermal project-related, general analysis of the return of investments in connection with the reduction of CO2 (carbon-dioxide) emission has not been made so far.
Geothermal assets in Serbia are mostly low-temperature ones, thus they are generally used for balneology, recreation, greenhouse and hothouse heating and heating of other buildings. The age of the exploitation systems is over 30-40 years. When they were designed and installed, no attention was paid to avoiding CO2 emission. Such data are not calculated, nor considered even today.

Sustainability Issues in Financial Context
In Serbia, the injection of geothermal water to reservoir is not mandatory and no attention is paid to the long-term sustainability of geothermal assets either.

List of Key Legal Acts and Regulations
- Law on the Confirmation of the Kyoto Protocol within the UN Framework Convention on Climate Change (RS Official Gazette no. 88/07 and 38/09)
- Law on Waters (RS Official Gazette no. 30/10 and 93/12)
- Law on Public Property (RS Official Gazette no 72/11)
- Law on Public-Private Partnerships and Concessions (RS Official Gazette no 88/11)
- Law on Energy (RS Official Gazette no. 57/11, 80/11 – correction, 93/12 and 124/12)
- Law on Efficient Energy Use (RS Official Gazette no. 25/13)
- Decision on confirming the Energy Development Strategy of the Republic of Serbia by 2015 (RS Official Gazette no. 44/05)
- Regulation on the conditions of power supply (RS Official Gazette no. 107/05)
- Law on Mining and Geological Explorations (RS Official Gazette no. 88/11)
- Protocol on defining annual programs on basic geological explorations in 2013 (RS Official Gazette no. 29/13)
- Regulation on the method of paying fees for the use of mineral resources and geothermal assets for 2013 (RS Official Gazette no. 118/12)
- Protocol on the content of geological exploration projects and studies on geological exploration results (RS Official Gazette no. 51/96)
- Protocol on the classification and grading of underground water reserves and of keeping records on them (RS Official Gazette no. 34/79)
- Protocol on the content of mining projects (RS Official Gazette no. 27/97)
- Protocol on the conditions and criteria for assigning the execution of geological exploration works and allocating sources for the execution of such works (RS Official Gazette no. 51/96)
- Protocol on the content of the feasibility studies on the exploitation of mineral resources localities (RS Official Gazette no. 108/06)
- Law on Planning and Building (RS Official Gazette no. 72/09, 81/09 – correction, 64/10 – Decision of the Constitutional Court, 24/11, 121/12 i 42/13)
- Protocol on the contents of information about the location and on the contents of location permit (RS Official Gazette no. 3/10)
- Protocol on the content and volume of preliminary works, preliminary ROI and ROI (RS Official Gazette no. 1/12)
- Law on Environmental Protection (RS Official Gazette no. 135/04 and 36/09)
- Law on Environmental Impact Assessment (RS Official Gazette no. 135/04 and 36/09)

SLOVAKIA

Financial constraints

There is no financial support/ subsidy scheme for investments in small-scale heat pumps (and/or shallow geothermal systems) used in households (family houses). Similarly, the heat produced in the geothermal heating plant connected to the grid is not supported.

On the other hand, the main instrument to support RES-E (incl. geothermal energy) in Slovakia is a feed-in tariff scheme, establish through the Act No. 309/2009 Coll. on promotion of RES. Responsibility for the implementation of the scheme lies with the Ministry of Economy of SR (MoE), as well as the Regulatory Office for Network Industries (RONI) and Slovak electricity transmission system. The Act and its amendments help with the market integration for RES. It sets a mandatory purchase of electricity produced from RES, until the specified fix output, for different types of RES.

<u>Tariff level for geothermal electricity plants:</u>

4. in operation before 1.1.2010 and during the year 2010: 195,84 €/MWh x coefficient (depending on the year of construction)
5. in operation from 1.1.2011 to 31.12.2011: 195,84 €/MWh
6. in operation after 1.1.2012: 190,51 €/MWh

(Decree of the RONI No. 184/2012 from 22nd of June 2012)

Investment subsidies from EU Structural Funds (2007-2013) for implementation of projects focused on RES utilization. Support to the projects in this field comes from two Operational Programmes – Competitiveness and Economic Growth and Environment. Within this programme there has been supported mainly: CHP installations, PV, small-scale hydropower plants, **heat pumps.**
Beneficiaries: self-governing regions, municipalities, state and public administration, private companies

Environmental fund (established under the authority of Ministry of Environment of the Slovak Republic) is composed of financial sources coming from environmental penalties and supplements collected in the economy. At the moment the fund is supporting only non profit projects meeting social needs through the following activities:
A/1a, A/1b: Heat and hot water preparation through low CO_2 emission and RES utilisation
A/1c: Heat and hot water preparation and electricity generation through RES utilisation for natural persons

It is expected investment support from Structural Funds in new programming period (2014-2020).

Environmental constraints (incl. Water rights)

Requirements related to geothermal water exploitation

Discharging geothermal water into surface waters can impact water quality by changing the acidity (pH) of the water, adding high levels of chemical contaminants (like arsenic), and increasing river temperatures.
Requirements related to geothermal water exploitation are laid down in the Act No. 364/2004 Coll. on water (Water act). Under this act, the competent authority shall issue a permit for the use of geothermal water (there are specified conditions/ requirements for discharging geothermal water to the recipient; emission limits – maximum allowable concentrations of substances in the discharged water).
Pollution standard, i.e. values after mixing discharged water with surface water, is laid down in the Government decision No. 269/2010. It also includes the limits for water temperature:

- temperature after mixing the water should not exceed 26°C
- for recipients intended for fish farming, these temperature should not exceed 28°C

Aproval/ Permitting process (incl. Land concessions, Building permits)

The process is under the authority of the Ministry of the Environment of SR/ MoEnv. SR:

11. Exploration/ exploitation permit – includes obtaining concession/ permit for use of the area of interest; (permission is given for 3 years, then it is possible to apply for an extension). Report on the use must be submitted to the MoEnv SR each year (information on the ongoing exploration and/or drilling).
12. EIA is required - the assessor is appointed by the MoEnv SR, but the applicant has to pay for assessment (this process also includes a public meeting in the respective municipality; the intention of the project must be presented to the public).
13. Relevant river basin determines the conditions for the discharge of geothermal water into the recipient (temperature of discharged water and its mineralization) in accordance with the Water Act and Government regulation/ (see above, Environmental constraints).
14. Approval of project realization by all institutions that are affected by construction: distribution system operators (gas/ electricity/ water), land owners, the competent national authorities (Regional Office for Environment, etc.) and to determine the conditions for the project realization.
15. Application for a building permit shall include: permit drilling and water discharge (issued by the competent Regional Office for Environment) and other construction permit (issued by the Building Authority in the affected area/ municipality).
16. Procedure for selection of supplier (one for all activities/ construction works) or suppliers (to supply technology, drilling, other construction works, etc.)
17. Conclusion of the contract.
18. After completion of drilling, the Final report is submitted for approval to the MoEnv SR (must be signed by the minister) - here are intended conditions of operation and after two years is revalued
19. Inspection
20. Commissioning/ putting in operation (permit is issued by the Regional Office for Environment and Building Authority), here are intended operating conditions

Reduction of CO_2 emissions

In Slovakia, the impact of geothermal projects on environment manifests itself mainly in reduction of emissions from burning solid fuels and natural gas which was the main objective of these projects.

The first company in Slovakia using geothermal energy for district heating by central heating supply was Galantaterm s.r.o. established in 1995. The most expressive results were achieved after starting up the operation of Galantaterm in 1997. From that time the quantity of emissions from gas is influenced by various objective factors and by factors of production in consequence of which the quantity of monitored emissions of CO_2, NOx, SO_2 and dust moderately increases or decreases.

Emissions derive from two sources, from geothermal water and natural gas:

- In the year 2011 CO2 emission from geothermal water of the wells FGG-2 and FGG-3 amounted to 8.35 t/y.
- The total of CO2 emissions from gas in the year 2011 was 388.48 t/y.
- The total of CO2 emissions from geothermal water and from gas was 396.83 t/y.

The main source of CO2 emissions in Galantaterm is natural gas. But the emission of CO2 would be much higher if geothermal water was not used. The main benefit of this project is the considerable reduction of emissions which is on average above 4000 - 5000 t/y (Environmental_Report_2011_EN.pdf).

Sustainability issues in a financial context

There is no obligation on geothermal fluids injection in Slovakia. When the geothermal systems was designed and realized no attention was paid to long-term sustainability of the geothermal resource. Used geothermal water is discharged into surface waters.
Based on the several analyzes, injection without financial support (e.g. from state budget, Structural Funds of EU, etc.) is unprofitable.
A good example of sustainable utilization of geothermal resources in Galanta, Slovakia could be improvement measures realized within the GEOCOM project (e.g. retrofitting of buildings, injection borehole research, etc.). Refurbished buildings need less geothermal energy, which can be used for longer DHW production and for the other main part of the CONCERTO area. In any case, realization of these measures would be unprofitable without financial support (co-financing).

List of main legal acts/ regulations and strategic documents

- Act No. 364/2004 Coll. on water (Water act) - requirements related to geothermal water exploitation
- Government decision No. 269/2010 – incl. pollution standard, i.e. values after mixing discharged water with surface water, etc.
- Act No. 17/1992 Coll. on environment - regulates the terms and conditions and the procedures for issuing environmental permits.
- Act No. 24/2006 Coll. Assessment of environmental impact - EIA
- Act No. 525/2003 Coll. the state administration of the environment
- Decree of the RONI No. 184/2012 from 22nd of June 2012 - tariff level for different types of RES
- Act No. 50/1976 Coll. on construction - regulates the terms and conditions and the procedure for issuing the building permit.
- Act No. 309/2009 Coll. on promotion of RES - this act and its amendments help with the market integration for RES. It sets a mandatory purchase of electricity produced from RES, until the specified fix output, for different types of RES.
- Energy Policy of SR (2006) – use of RES
- Strategy of higher utilization of RES in Slovakia (2007)
- NREAP (2010) - mandatory national target for the Slovak Republic

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