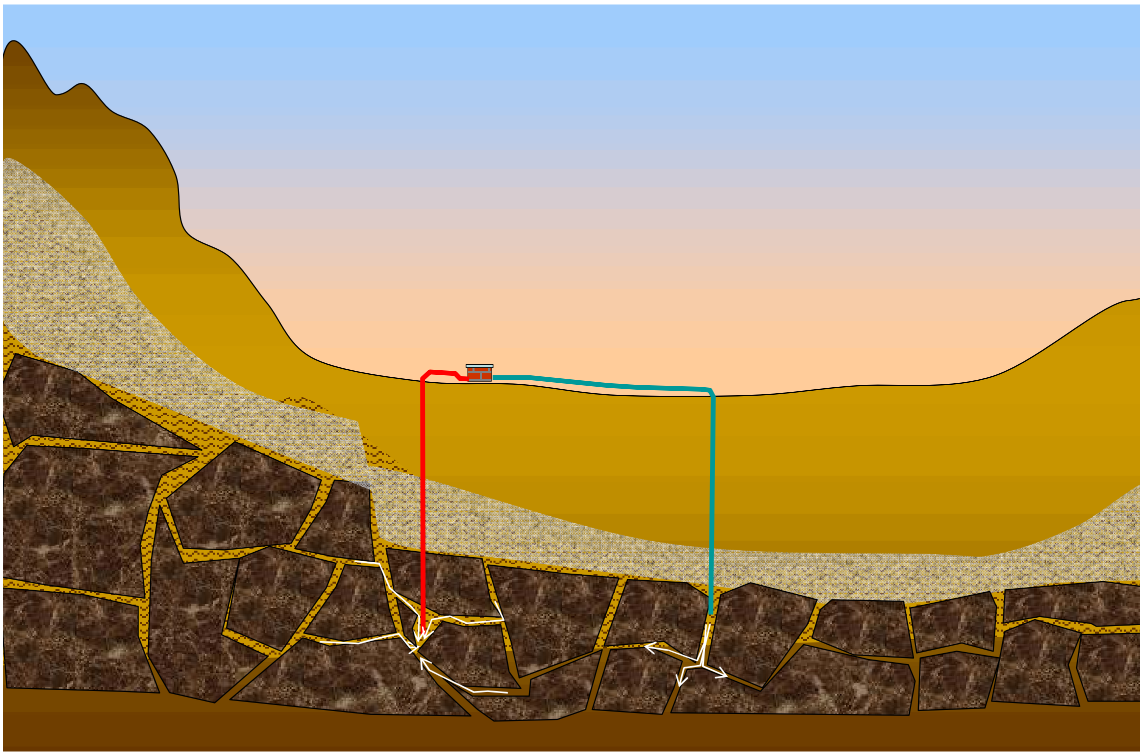
Geothermal energy sources as opportunity for Turkish greenhouse horticulture and the Dutch commercial sector

H.F. de Zwart & M.N.A. Ruijs



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H.F. de Zwart & M.N.A. Ruijs

Wageningen UR Greenhouse Horticulture, Wageningen
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Report 225

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The Agricultural Counselor of the
Embassy of the Kingdom of the Netherlands

Wageningen UR Greenhouse Horticulture

Address	:	Bornsesteeg 65, 6708 PD Wageningen, The Netherlands
	:	Postbus 16, 6700 AA Wageningen, The Netherlands
Tel.	:	+31 317 – 48 56 06
Fax	:	+31 317 - 41 80 94
E-mail	:	greenhousehorticulture@wur.nl
Internet	:	www.greenhousehorticulture.wur.nl

Contents

Introduction

Due to the favourable soil, water and climatic conditions, Turkey is a major producer of agricultural products. The increasing standard of living in the large domestic market and the surrounding countries and the development of trade possibilities to the EU market induces special possibilities for the horticultural sector, including the protected cultivation in greenhouses.
Greenhouses perform best in climate conditions with much light, moderate temperatures and low humidities. Except for the two hottest month's, large areas in Turkey suit these demands.
However, moderate temperatures during the day often imply low temperatures during the night and morning. This means that greenhouses benefit a lot of a heating system.
With respect to heating in a sustainable way, Turkey has large possibilities in utilizing it's geothermal potentials. Large parts of the country appear to contain heat in underground water-filled cavities at 500 to 1500 m depths. Currently, in almost 200 areas, this geothermal heat is used in a substantial way. Most of these applications are meant for municipal district heating systems. In a smaller number of cases the geothermal heat is used for greenhouse heating and in two locations the geothermal heat is used for electricity production.
Since the estimated potential is very much bigger than the actually applied geothermal heat, Turkish policy makers anticipate on a strong growth in the coming years.
When combining the anticipated growth of geothermal energy, the suitability of greenhouses to add value to geothermal energy and the anticipated growth of horticulture, it is worthwhile to investigate the opportunities of an improved application geothermal heat in Turkish greenhouse horticulture.
Therefore, the Agricultural Counsellor of the Embassy of the Kingdom of the Netherlands asked the Greenhouse Horticultural business unit of Wageningen University and Research to do a survey on this topic.

1 Technique of geothermal heat application

The subsoil of large parts of Turkey is constituted of marble and marble-like rocks. Marble is a relatively soft type of rock which makes it not too difficult to drill deep wells. Moreover, the earth crust in this area is relatively thin which makes that internal heat from magma flows deep within the earth's centers is conducted relatively well to fairly reachable depths This makes that, when drilling a hole to some 1000 meters depth, in large areas of Turkey one will find underground temperatures ranging from 40 up to even more than 200 °C.
Typically, in many area's the rocks deep down are not large solid volumes, but full of cracks. These cracks are filled with water that originally comes from rain in the surrounding mountains. In some places, when drilling a pit to these cavities, the pressure on the water in the rocks is that high that the hot water comes out of the drilling hole by itself. However, in general, the flow rate of these open systems is limited. A more common situation is a well where a submersed pump or a deep well pump pumps up the hot water.
Until recently, geothermal heat applications were based on one borehole only, which means that the water, after application of the heat, ran off to a ditch.

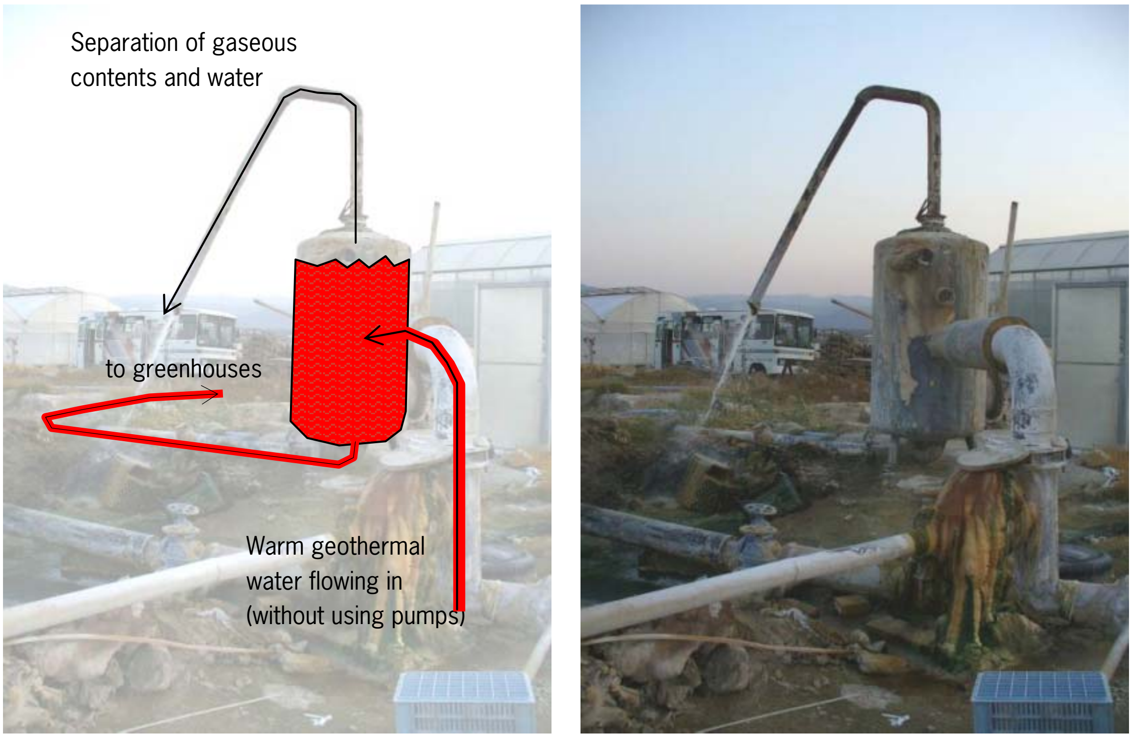


Figure 1.1. An open geothermal heat application (photo taken at Goncuoglu Farm, Manisa).

Because of the growing awareness of the importance of guarding the surface water quality, but also in order to improve the applicability of geothermal heat on a larger scale, these open systems are no longer allowed to be built. New geothermal plants have to be based on closed systems. This means that there is a well where hot water comes out, either by means of pumping or from itself, and a second well where the water is re-injected into the underground layers. Of course the latter one has to be pressurized, which means that a closed system will always use more electricity than a comparable open system.
In this way, pollution of above ground water resources is prevented, but also it preserves the pressure head in the geothermal wells. After all, all water extracted from the hot well has to be replenished somehow. Unless there are real underground rivers, flow from the area surrounding the well is quite limited due to the rocky structure (water can only flow through cracks in the rocks).

When using a closed system it is most common to use a heat exchanger that separates the geothermal water from the water that circulates through the system that applies the heat. This avoids that the mostly chemical aggressive geothermal water can corrode the piping of the application. By placing a heat exchanger, the need of a corrosion-resistant materials is minimized.

Figure 1.2. *A plate heat exchanger that separates the geothermal water from heating system water that circulates in the heating system of a greenhouse (photo taken near Dikili).*

The picture below gives an impression of the complete setup of a geothermal heat source. The hot water flows through cracks in the rocks towards the extraction point. The re-injection point should be placed at enough distance (some kilometers) and downstream from the production well.

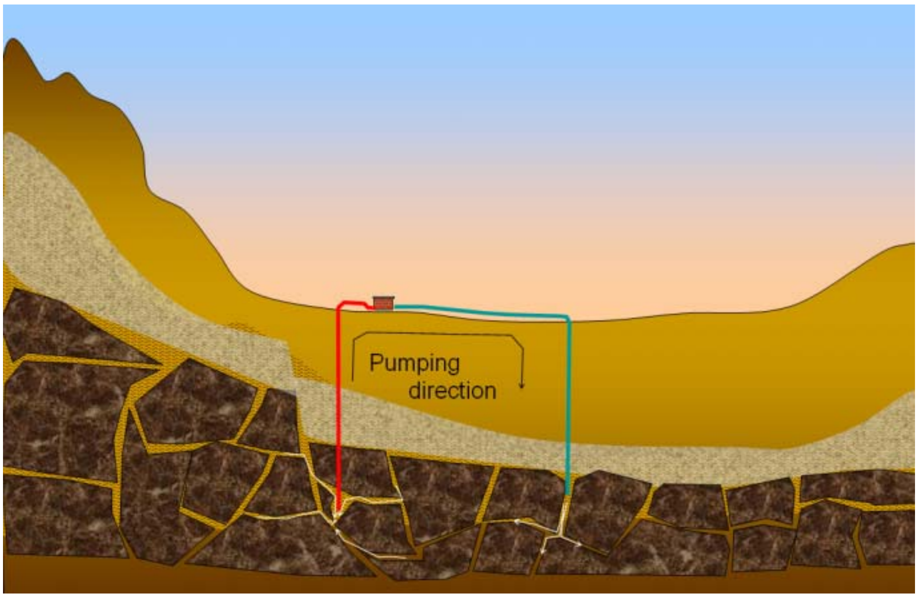


Figure 1.3. *A closed geothermal heat system pumps up water from a hot geothermal well and re-injects the water at a lower temperature at some distance.*

Besides using geothermal heat for greenhouse heating directly from a well, greenhouses can also be heated with the remaining heat of geothermal energy used for electricity production. This will be discussed in more detail in chapter 5.

2 Main geothermal areas

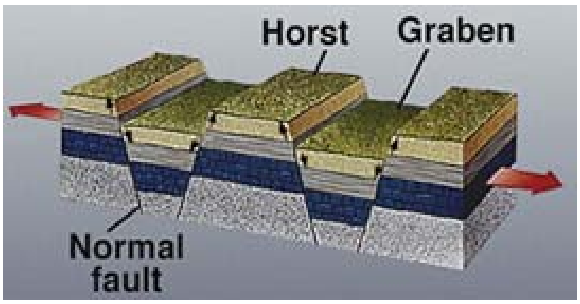
2.1 Introduction

Turkey has a unique geographic position at the crossroads between Europe and Asia. It is located on an active tectonic, orogenetic belt, the Alpine-Himalaya Orogen with young faults and active volcanism which is the reason for Turkey's substantial geothermal resources.
Most of the geothermal energy potential is located in the Aegean and Central Anatolian region (see Figure 2.1).

Figure 2.1. Geothermal areas in Turkey (source: General Directorate of Mineral Research and Exploration, Ankara).

The total geothermal potential in Turkey is estimated to be about 31,500 MWt.
When counting all hot water reservoirs with temperatures above 35 °C, the proven geothermal capacity of the existing wells and springs in Turkey is about 3928 MWt (calculated by the General Directorate of Mineral Research and Exploration of Turkey, further on abbreviated as MTA).
Turkey holds a significant potential for geothermal energy exploitation. Currently, 187 geothermal fields are in operation. The most current fields are located in western Turkey because of large amount of grabens that can be found there as a result of recent tectonic activities.

The picture explains the geological term 'graben', which is a long channel-type caving of the earth crust along fault lines.
Because of the crushed subsoil structures, the porosity around these fault lines is relatively large. This means that when a well is drilled towards these areas water can flow from the surrounding to the suction point. Also from the re-injection point water spreads relatively easy to the surrounding.



Picture from Wikipedia.

Low- and moderate- temperature sources can be found in Middle- and Eastern-Anatolia because of volcanism and fault formations and in the north, along the North Anatolian Fault Zone
The main uses of geothermal energy in Turkey cover a wide range of applications, such as space heating and domestic hot water supply, greenhouse heating, swimming and balneology, industrial processes and electricity generation. However, the application of geothermal energy for district heating systems predominates.

2.2 Legislation on geothermal energy resources

Recently the Turkish government has issued a law on geothermal resources and natural mineral water (see Appendix 2 for highlights and Appendix 3 for the full text).
The legislation organizes the procedures from the exploration stage to the production stage and the financial aspects of the application of geothermal heat.
Licenses can be obtained from local authorities but the nation wide administration on these licenses is centralized by the General Directorate of Mineral Works (MIGEM).
Licenses can be permitted for existing wells and for newly explored wells. Existing wells can be sold and bought as a kind of commodity.
For new wells, every legal individual can apply for an exploration license. This license gives someone the exclusive right to judge the geothermal potentials of a certain bounded area within a three years time (conditionally extendible with a 4th year). If the location appears to be all right the exploration license can be transformed into a business license. A business license gives a 30 years right and can be prolonged with 10 years periods.
When having a license, a number of fixed administration costs must be paid and, apart from that, an amount of 1% of the annual turnover of the enterprise that uses the geothermal heat is charged.

In the past years, in order to boost the development of geothermal heat applications, the governmental General Directorate of Mineral Research and Exploration (MTA, see Appendix 2 for further details and address data) has explored 34 new geothermal fields. For these fields, estimations are made for the production capacities and operation conditions (temperature, pressure, flow rate characteristics). For some of the geothermal fields, MTA has even made a full production ready well.
In the last quarter of 2008, all the fields recently explored by the MTA are offered to be licensed to private investors according to a tendering system. This means that the production license will be transferred to the highest bidding company.
Among these 34 locations, 6 locations are expected to be suitable for electricity production because of their high temperatures. Due to this special character, these 6 geothermal areas (four in the Aydin region and two near Manisa) are tendered first, followed by the other 28 locations in a later stage.

Parallel to the coordination of the tendering procedure, MTA continues with the exploration of new potential fields. With the current exploration speed, some 5 new locations will become available annually.

3 Greenhouse area and geothermal energy applications

3.1 Greenhouse area

The total area in Turkey with protected cultivation was almost 18,000 ha in 2006. Near 13,000 ha was covered with plastic or glass greenhouses and some 5,000 ha was covered with low and high tunnels (see Table 3.1). During the past 5 years the yearly increase of the greenhouse area was more than 10%. From the greenhouses, 30% has a glass cover and the other greenhouses have a plastic foil covering. The area with plastic tunnels consist mainly of the low type tunnel.

Table 3.1. Horticultural area under protective cover in Turkey in 2006.

Province	Area under protective cover (ha)	Area under glass greenhouse (ha)	Area under plastic greenhouse (ha)	Area under (low/high) tunnel (ha)
Turkey	17900	3962	8879	5058
Of which:				
Adana *	3999	-	269	3730
Afyon *	-	-	-	-
Amasya	83	-	56	27
Ankara	16	-	16	-
Antalya	7636	2944	4605	87
Aydin *	214	10	150	54
Balikesir *	1	-	1	-
Bilecik	51	38	13	-
Bolu	13	-	13	-
Bursa *	67	48	10	9
Canakkale *	61	-	61	-
Cankiri *	157	17	140	-
Denizli *	70	9	9	-
Hatay	64	-	29	35
Isparta	263	14	249	-
Mersin *	3269	454	1876	939
Istanbul	60	4	40	17
Izmir *	319	12	266	41
Kirklareli	15	15	-	-
Kocaeli	33	5	26	2
Kutahya *	3	3	-	-
Manisa *	97	-	97	-
Mugla *	772	301	468	3
Ordu	66	13	64	-
Samsun	116	-	116	-
Sinop	58	1	3	54
Zonguldak *	44	12	19	13
Bartin *	32	0	18	14
Yalova *	188	34	154	0
Karabuk	50	2	25	23

* *Provinces with (high) potentials for geothermal greenhouse heating; processed by WUR.*
Source: LNV-VB Ankara, Turkey.

The main greenhouse areas are located in the Mediterranean region (Antalya, Mersin and Adana; together they have 83% of the total Turkish greenhouse area). About 70% of the total glass greenhouse area is situated in the Antalya region.

The last few years the Izmir-Dikili region has become popular for large scale greenhouse investors. This is enhanced by the available geothermal energy resources for greenhouse heating. In Figure 2.1 the (major) geothermal areas are shown. With this information, Table 3.1 show also the regions which might have (high) potentials for geothermal greenhouse heating (marked with *).
For the near future, the Turkish authorities expect that new greenhouse investments will concentrate in the western and south-western part of the country (Izmir, Aydin and Mugla provinces) and in east Mediterranean region (Mersin and Adana provinces). The reasons are that large scale agricultural land will become scarce in the region of Antalya due to small scale parcels and the strong pressure from the tourism sector. Besides that the costs of energy (of natural gas, coal and LPG) will increase and therefore geothermal energy applications will become more attractive.

3.2 Geothermal greenhouse heating applications

The MTA has made an inventory of the current geothermal energy applications in greenhouse areas and made also projections for the year 2013 (Dağıstan, 2008). The existing situation and projections for 2013 are described in Table 3.2.

Table 3.2. Existing situation (2007) and 2013 projections in geothermal greenhouse heating in Turkey.

Place	Greenhouse Area Hectare	Estimated Power (MWt)	2013 Projections Estimated (hectare)	2013 Projections Estimated (MWt)
Izmir-Dikili	60	116	100	193.3
Denizli-Yenicekent	0.5	1	10	20.0
Denizli-Sarayköy	2	3.92	40	78.4
Manisa-Salihli	20	39.2	40	78.4
Manisa- Urganli	2	3.5	7	12.3
Kütahya-Simav	20	40	35	70.0
Aydin-Gümüşköy	6	9	10	15.0
Afyon-Sandikli	1	1.96	20	39.2
Nevşehir-Kozakli	0.45	0.88	2	3.9
Urfa	4	8.2	8	16.4
Izmir-Balçova	4.4	8.52	10	19.4
Kirşehir-Mahmutlu			20	38.7
Izmir-Aliağa-Samurlu			20	40.0
Manisa-Kula			10	19.6
Balikesir-Balya			5	9.8
Denizli-Gölemezli			15	26.3
Total	120.35	232.18	352	680.6

Source: Dağistan, 2008.

Table 3.2 points out that the existing geothermal greenhouse heating applications are mainly located in the western part of the country (especially Izmir, Manisa and Kutahya) and represent a greenhouse area of 120 ha with an estimated power of 232 MWt. The largest geothermal greenhouse applications are situated in Izmir, Manisa, Kütahya and Aydin.

Towards 2013 the MTA assumes that the greenhouse area will increase to 350 ha and the estimated geothermal power for greenhouses will extend to 680 MWt. The extension shall be mainly realized in existing greenhouse areas (160 ha and 340 MWt).
The extension of geothermal energy applications in greenhouses is expected to take place in the western part of the country. Furthermore also in central Turkey (Nevsehir and Kirsehir), geothermal energy applications will occur. It is not clear why areas like Mersin and Adana are not mentioned in the list of horticultural geothermic development projections.

It is difficult to judge whether the estimations of the MTA are valid. Which assumptions have been used for the above mentioned estimations? Furthermore it is not known whether the MTA has taken into account in his 2013 projections the possibilities of combined use of geothermal energy by power plants and greenhouse farms.
Prof. Satman of the Institute of Energy (Istanbul Technical University) pointed out that the estimations are somewhat optimistic looking from an technical point of view.
Nevertheless the greenhouse areas which can be supplied with geothermal energy can increase considerably when the conditions and circumstances are favorable (such as high energy prices).

3.3 Prospects of geothermal greenhouse heating application

In the current situation geothermal greenhouse heating applications are used individually. Greenhouse entrepreneurs have bought licenses from local authorities to apply geothermal heat. It is to be expected that the costs of the licenses will increase in the future, because of the tendering procedure of areas that are explored by MTA (license goes to the highest bidder), but especially because it is likely to expect that energy prices of any source will reflect the value of alternative sources (such as fossil fuels).
Typically, when using geothermal energy, an entrepreneur pays high initial costs and low running costs. The running costs are determined by electricity costs for running the pumps (which are around 5 kWh per GJ) and a fee of 1% of the annual turnover. The initial costs are very much dependent on locational factors. The depth, the geological constitution, the temperature and the pressure needed to pump water from the production well to the re-injection well are different for every specific location. Moreover, when an entrepreneur wants to explore a new area, there is hardly any guarantee for success, which means that there must be some provision that carries the risks in case of a disappointing production capacity. The uncertainties are very much lowered when buying a license from previously explored by MTA. In some cases, on behalf of the exploration, MTA has even built completely ready to use production wells. However, these advantages have a price, also because of the tendering policy of the MTA.
As a rough estimate of the investment for geothermal heat MTA mentions investments of around $ 300 thousand per MWt (Dağıstan, 2008), but depending on the installed capacity, the running costs for heating can drop up to 90%.
However, unlike when using natural gas for heating a greenhouse, geothermal energy might induce a shortage on CO_2 dosing. Some wells show to produce large amounts of CO_2, (the well at Sultanishar produces up to 7 tons of CO_2 per hour) but in those situations these gases can be contaminated with other gases as well, which means that it needs sophisticated cleaning technologies to extract the CO_2 from the aquifer water. Moreover, this CO_2 has a clear market value and is, therefore, not directly comparable to exhaust CO_2

Nevertheless, according to the Turkish greenhouse entrepreneurs with whom we have spoken (see Appendix 2) geothermal energy application in greenhouses is economic feasible. Especially when looking at the current high energy price for natural gas.

Another development that helps the growth of geothermal energy in an economic feasible way is the combined application of this heat for power generation and heating purposes. As can be read in chapter 5, power generation is always accompanied with a large amount of reject heat. From technical point of view, this reject heat is a reliable

heat source for greenhouse heating applications so this offers perspectives for greenhouse farms to settle near power plants.
However, in order to realize such projects, serious organizational problems must be overcome. One problem is that the locational demands for greenhouses limits the number of alternatives to set up a combined greenhouse and power plant. Greenhouses require a proper connection to the infrastructure for the frequent transportation of resources and the produce and the availability of labor. The biggest difficulty however is that the time path's for setting up and running a greenhouse plant differ quite a lot from setting up a power generation plant.
Nevertheless, the greenhouse sector should realize that the Turkish authorities are very keen on the application of geothermal energy for electricity production. A cooperative action of the greenhouse sector and power plant companies together might create favorable positions in land acquirements.

3.4 Spin-off of geothermal greenhouse heating

Besides that geothermal greenhouse heating is likely to be attractive from energy costs point of view, the application of geothermal heat also offers possibilities to improve the production level and quality. In this respect, investments in geothermal heating application could act as a trigger for further intensification of the production processes.

In general, the increase of capital stimulates the grower to search for additional options to improve the performance of the greenhouse farm. These options could be the choice of specific varieties (with a higher energy demand and higher production), lengthening of the cultivation period, (additional) use of fluid CO_2 and cultivation on substrates. Moreover, information and monitoring systems (ICT) can help the growers to improve the quality of the production processes and to support the management control of the farm.

It is commonly known that Turkish entrepreneurs are price oriented. Added value of higher investments is hardly a criterion in the selection process of production systems. Therefore most Turkish growers choose for the cheapest greenhouse structures or other technologies. The question is how these entrepreneurs can be convinced of the opportunities of using higher technological standards for greenhouse horticulture.
This question is one of the main topics of the 2g@there program 2008-2012 of the Dutch Ministry of Agriculture, Nature and Food safety and the Dutch association of suppliers of greenhouse technology.
On the other hand, SERA-BIR – the association of Turkish investors in (greenhouse) horticulture – stimulates the increase of production and yield. SERA-BIR is aware that production improvements can't be achieved with only simple equipment. SERA-BIR members are not typical horticultural growers, because they have gained their capital in other sectors (textile, building, etc.). SERA-BIR represents the interest of large modern producers, who represent 450 ha of greenhouse production and have intentions to extend to 1500 ha within 5 years. It is to be expected that those entrepreneurs would like to fulfill their extension plans by settling near geothermal energy fields.

3.5 Impact on strengthening the Turkish greenhouse sector

The application of geothermal greenhouse heating can give a boost to the development of the greenhouse sector. Especially the (greenhouse) areas in western and south-western Turkey could profit from that development. Also the east Mediterranean region of Mersin and Adana have good prospects, but the application of geothermal greenhouse heating is apparently not foreseen by the MTA.

The geothermal greenhouse heating application can be expected to be realized by the bigger investors. They have a better negotiation position than small greenhouse farms. Not only in the case of obtaining the necessary licenses to produce geothermal heat itself, but they are also a more interesting party for power plants to cooperate with. Therefore smaller greenhouses farms could better join their activities, but this will require another cooperative attitude and behavior of the entrepreneurs.

The application of geothermal heat in greenhouses can stimulate investments in other technologies in order to improve the quantity and quality of the greenhouse products. With a higher production quality the Turkish greenhouse sector can improve its competitive strength on the international market.

4 Opportunities for the Dutch horticultural sector

With respect to geothermal greenhouse heating application there is no specific advantage for Dutch companies in supplying equipment for exploring and producing geothermal heat. Nevertheless the application of geothermal greenhouse heating can give a boost to the development of protected cultivation in Turkish horticulture. This development can be revealed by the growth of the area of (plastic and glass) greenhouses and/or by an intensification of the production process (in current greenhouses). From this point of view the opportunities for the Dutch horticultural sector are on the following fields:

- export of knowledge of cultivation techniques to Turkish growers and/or to the extension services. This can be realized by developing courses or trainings and/or can also be achieved by establishing a demonstration and education centre for the Turkish horticulture (in a joint venture or partner ship). The target groups are the managers and the middle management.
- export of greenhouse structures with plastic and/or glass covers;
- export of greenhouse equipment related to the intensification of the production process;
- export of management supporting systems for a better process and management control
- guidance of planning, implementation and realization of high technology standards in Turkish greenhouse horticulture. This guidance can be given in a broader perspective, e.g. from a chain point of view.

Turkish entrepreneurs are commonly price oriented and therefore choose the cheapest techniques and technologies. In order to initiate a movement in that attitude and behavior, the experiences of Turkish entrepreneurs using high technology standards (from The Netherlands) can be useful.
The above mentioned opportunities are not directly related to the use of geothermal resources for greenhouse heating. These opportunities are also the focus of the 2g@there program 2008-2012 of the Dutch Ministry of Agriculture, Nature and Food safety and the Dutch association of suppliers of greenhouse technology.

5 Electricity production

Electric energy is twice to three times as valuable as thermal energy and the growing demand for electricity makes investments on electricity production from geothermal sources a potential interesting activity.
In Turkey, currently there are two geothermal power plants in operation. One of these enterprises, the Mege Geothermal Elektrik Santrali near Aydin (Coordinates: 37° 52' 26.71' N, 28° 06' 28.10' E) was visited during the trip. This power plant has a maximal electric power output of 8.5 MW but runs normally at a power level between 5 and 6 MW.
The sketch below shows the basics of the thermodynamic scheme.

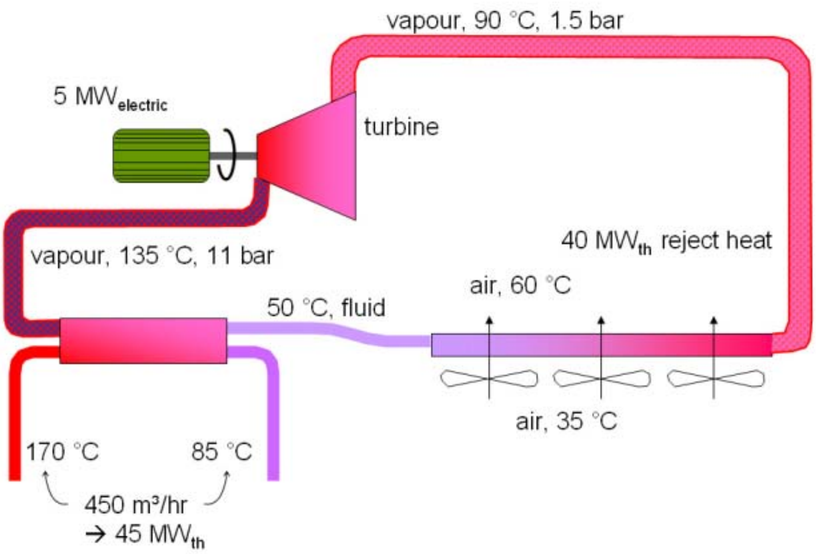


Figure 5.1. Simplified flow scheme of the geothermal power plant at Mege Geothermal Elektrik Santrali.

As can be seen in the picture (with typical figures holding for the plant near Aydin) only 11% of the heat extracted from the geothermal reservoir is converted to electricity. Almost all of the remaining 89% of the extracted heat is rejected in the ambient air by the cooling section of the power plant.
At first sight, this 11% conversion efficiency looks very small but since the conversion efficiency of every heat engine is limited by the temperature difference between the highest and lowest temperature around the turbine the Mege Geothermal Elektrik Santrali must be judged as a plant that works at about the maximum possible conversion efficiency.

The thermodynamics of power generation also clarify the importance of the temperature level of the well. In case the temperature level of the geothermal heat around Aydin would have been 200 °C instead of 170 °C the potential conversion efficiency would grow to 16% and, combined with the grown thermal power, the electric power that could have been produced by the same 450 m^3/hr flow rate would be around 7 MW.
In case the well would give only 150 °C water, the potential electric power at a flow rate of 450 m^3/hr would drop to 3.6 MW.

Apart from the 40 MW of reject heat that is released to the ambient air, the figure shows that the temperature of the re-injected water is still at quite a high level. Greenhouses (or domestic heating applications) can still withdraw a large amount of heat from this re-injection water.

For greenhouses it is quite common to apply a heating system based on water with a supply temperature of 50 to 80 °C and a return temperature of 35 to 40 °C. Assuming the latter return temperature, a greenhouse could lower the temperature of the water returned to the re-injection well to 45 °C (taking into account a 5 °C temperature loss across the heat exchanger that separates the geothermal water from the water circulating in the greenhouse). Cooling water from 85 to 45 °C at a flow rate of 450 m^3/hr means a heating power of 21 MW.
Thus, by adding only one heat exchanger (but some 10 times bigger than the one depicted in Figure 1.2) a power plant like Mege Geothermal Elektrik Santrali could serve the full heating load of 15 to 20 hectares of greenhouses and a substantial contribution to the heating of greenhouses in case a larger area would be served by this geothermal heat source.

Indeed Mege Geothermal Elektrik Santrali is trying to build a joint ventures with greenhouse entrepreneurs. However, up till now this has not yet resulted in concrete results. A currently new building greenhouse entrepreneur, building a 4 hectare greenhouse at a distance less than 3 km from the power plant, could not be convinced of the advantages of the application of this reject heat.

6 Conclusions

- The possibilities of geothermal energy in Turkey, especially for horticulture are large indeed.
- The tendering procedure as it is organized by the MTA hardly fits to the current business structure in horticulture. The tendering procedure of the MTA results in the provision of business licenses for ‘naturally bounded areas’ with dimensions of some 5 to 10 km^2 to the highest bidding real or legal individuals. To avoid interaction, the geothermal areas are widely interspaced. Since in the current Turkish way of doing business cooperative actions of individual growers are not very likely to take place, this can only result in a very scattered development of geothermal energy for greenhouses. This development is contradictory to the frequently mentioned mutual benefits for growers when they are located in conglomerates. Also, this policy leads to a strong limitation to the greenhouse area that can profit from geothermal energy.
- Besides participating in the tendering procedures of the MTA, according to the ‘Law On Geothermal Resources And Natural Mineral Water’, individuals can apply for an exploration license and business license directly at local authorities. These authorities can provide licenses for much smaller sites, which means that this would better suit horticulture.
- Turkish policy makers are very keen on the application of geothermal heat for electricity production since the demand for electricity grows rapidly.
  For the few power plants in operation or in development, only about 30% of the energy content of the geothermal heat is used. This because re-injection temperature is far above environment temperatures (*e.g.* 80 °C).
  Application of this reject hot water for greenhouse heating can add substantial value to both horticulture and a geothermal power plant.
  It is advisable for growers to investigate the possibilities of settlement near geothermal power plants and start negotiations with the owners of these power plants.
- As geothermal energy originates from heating from within the inner heat of the earth, substantial extraction of heat to the surface can cause a slow decrease of the temperature of the geothermal energy. Greenhouse heating systems can easily adapt to this situation by enlarging their heat exchanging surface, but electric power plants will encounter a significant loss of conversion efficiency.
- The availability of CO_2 for greenhouse air fertilization is a key-requisite for high production levels, especially when the heating system is based on geothermal energy.
- The application of geothermal greenhouse heating can give a boost to the development of the Turkish greenhouse sector. It offers possibilities to improve the production level and the quality by further intensification of the production process.
- (Greenhouse) areas in western and south-western Turkey will probably profit most from the opportunities of geothermal energy application. The east Mediterranean region of Mersin and Adana have also good prospects, but the application of geothermal greenhouse heating is apparently not foreseen in the coming 5 years.

The opportunities of the Dutch horticultural sector in Turkey are not particularly related to the application of geothermal greenhouse heating. In general the opportunities are on the following fields: transfer of knowledge of cultivation techniques, export of greenhouse structures, internal equipment and management support systems and guidance of the implementation of higher technology standards, especially from a chain point of view.
From that perspective the initiative of the 2g@there program 2008-2012 of the Dutch Ministry of Agriculture, Nature and Food safety and the Dutch association of suppliers of greenhouse technology have to be mentioned. This program is aiming at the establishment of a network of Dutch and Turkish parties with respect to the business development of greenhouse horticultural production in Turkey.

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Appendix I.

Program study tour Geothermal energy sources and Turkish greenhouse horticulture

2 September 2008
Organised for the 2g@there programme by the Agicultural Counsellor of the Embassy of the Netherlands in Ankara
Agrobay Greenhouse Company - Mr. Hasan Şentürk (director)
Bergama/Dikili – Izmir

Lider Food Company (Greenhouse complex) – Mr. Saadettin Altuntas (manager)
Manisa

Goncuoglu Farm - Mr. Murat Goncuoglu (owner)
Manisa

3 September 2008
Organised for the 2g@there programme by the Agicultural Counsellor of the Embassy of the Netherlands in Ankara
Aydın Chamber of Commerce – Mr. Mustafa Bastug (Head of Managing Board)
Aydın

Mege Geothermal Elektrik Santrali
Aydin

Izmir Chamber of Commerce
Izmir Economic University – Mr. Prof. Dr. Cemali Dincer (Vice Rector)
Izmir

4 September 2008
Mineral Research and Exploration General Directorate – Mr. Hayrullah Dağıstan (Head of Department Energy Raw Materials Research and Exploration)
Ankara

5 September 2008
Instanbul Technical University
Institute of Energy – Mr. Prof. Dr. Abdurrahman Satman (Director)

The tour on 2 and 3 September 2008 was in cooperation of and organized by the 2g@there program 2008-2012. This program is focused on the business development in horticultural greenhouse production in Turkey in the period 2008-2012.

Appendix II.
Brief report of the study tour

Agrobay Greenhouse Company - Mr. Hasan Şentürk (director)
Bergama Sahancı Köyü, Kaynaraca Mevkii
*Bergama/**Dikili** - Izmir*

Mr. Hasan Şentürk is director of Agrobay and also chairman of the association of investors in horticultural sector SERA-BIR. Agrobay Greenhouse Company has at the moment 35 ha of greenhouses and this will extend to 50 ha within some months. The greenhouses mainly consist of structures with a plastic cover, a smaller part has a glass cover.
During spring, summer and autumn mr Şentürk prefers plastic structures above glass because of the lower light transmission and subsequently lower rise of the greenhouse temperature. In the coldest part of the year a greenhouse with a glass cover is preferable because then both light and warmth are needed. The greenhouse units have a size of 2 to 4 ha. The cultivation of vegetables is on substrate (rockwool or perlite).
Agrobay uses geothermal energy for their energy supply. Unfortunately, during the visit there was too short time to be informed about the technical and economical aspects of this geothermal energy.

Nearby Agrobay a quick visit was made to a two years old greenhouse vegetable farm, which is also using geothermal energy. In this case a closed system is being used, meaning that the outlet water is re-injected in the soil.

SERA-BIR

SERA-BIR is the association of investors in (greenhouse) horticulture. Main part of the Turkish greenhouse sector is situated in the Antalya region. The majority of the producers cannot produce during summer period due to temperatures too high. SERA-BIR intents to represent the interest of large modern producers which are able to produce year-round. SERA-BIR members represent at the moment 450 ha covered production. This number is expected to grow to 1500 ha within five years. It is expected that the total area of covered greenhouses will be 5000 ha within 5 years. SERA-BIR members are not typical agricultural companies; investors have gained there financial means in textile, building, metal etc.

Actually investors are hesitating with investments since a number of problems need to be resolved first:
- Access to geothermal energy sources need to be secured
- Land acquisition for greenhouse horticulture needs to be regulated
- Experienced management and skilled workers are scarce but necessary.

According to SERA-BIR, the Turkish government (Ministry of Agricultural - MARA) does not provide sufficient support to the investors in the greenhouse horticultural sector. The investors and company managers in the greenhouse sector need to have the skill to overcome all problems by themselves. The government has been asked by SERA-BIR to support the development of the greenhouse sector by designating land with geothermal energy sources. However SERA-BIR has little expectation about the cooperation of the Turkish government. In order to be independent from foreign gas, the geothermal sources could support the development of the 1500 ha greenhouse. During recent years the local government grants the permissions to the investors to use the land where the sources are available. All known geothermal sources are now in private hands aiming at selling for a higher price or invest themselves in the utilisation of the energy sources.

SERA-BIR stimulates the increase of the yield with 40-70% (from 35 kg/m^2 now to 60 kg/m^2). This can be realised by greenhouses with glass cover as well as with plastic cover. Nevertheless glass greenhouses are likely to offer better

possibilities to apply modern techniques resulting in higher production results. SERA-BIR has made analysis of the Turkish market for green house technology.
A presentation of this study can be downloaded from
www.sera-bir.org.tr/userfiles/file/s.kefi_presentation_28.11.08.pdf

Address data of SERA-BIR:
Işık Sokak 20
Tandoğan / Cankaya - Ankara
Tel: 0 312 229 08 08
E-mail bilgi@sera-bir.org.tr
Internet: www.sera-bir.org.tr

Lider Food Company (Greenhouse complex) – Mr. Saadettin Altuntaş (manager)

Greenhouse adress: Hasalan Köyü Salihli

Manisa

Lider is the biggest exporting company of Turkey. Previously Lider bought al products from other producers. In order to secure sufficient and quality produce, Lider initiated their own production since April 2007. The own production site was constructed with production facilities for tomatoes (variety Bandita); since September 2007 production has been launched on the scale of 10,5 ha. At the moment there are 65 workers; they need continuous attention (social and discipline aspect). The production target is 30 kg/m^2 (Turkish average is 25 kg/m^2).
Antalya and Dikili have higher global radiation than Manisa. Humidity is lower in Manisa than in Antalya.
In the next season the cultivation will be supported by liquid CO_2 although the prices are high (around 0.18 €/kg (in the Netherlands this price is around 0,10 €/kg)).

Geothermal energy is being applied at the site. Water is coming from 1100 meter depth and has a temperature of 80°C. By a recent published state law it is compulsory to re-inject the outlet water in order to protect the geothermal resources. The payment of use of geothermal energy is administered by the local authorities for the registration of the initial license. The use of the geothermal energy is free but there are supplementary costs as a consequence of the compensation of fluctuations in flow and in temperature. At the site, a heat storage tank is available to set off the fluctuations. It seems that the flow is somewhat decreasing. This maybe due to the developments in the surrounding urban areas. According to mr Altuntas, the investments for drilling are 3,50 € per meter depth (incl. taxes). Lider operates three wells; two are used to pump the water out and one well is for re-injection.
The greenhouse complex in Manisa has a energy supply back-up of coal in case of.
In comparison with the production area in Antalya, Manisa has the advantage of geothermal energy. For Lider this means almost a reduction of 30% of the energy costs. In Antalya there is the future possibility to use natural gas which is very expensive now.

Future investment plans of Lider include the further expansion towards 35 ha of covered production. First the energy supply by geothermal energy have to be secured. At the moment Lider is negotiating with the local government about the permit.

Goncuoglu Farm - Mr. Murat Goncuoglu (owner)

Manisa

A short visit was made to Goncuoglu farm. This former arable farmer started some years ago producing greenhouse products (vegetables). Problems with diseases in seeds and young plants of arable products was the reason why Concuoglu made the shift to greenhouse production.

Geothermal energy is being used via a so called open system (see Figure 1.1). The water comes from 500 m depth (without pumping) and has a temperature of 75°C. After using the heat, the water runs off to the soil. The outlet water contains a high level of bicarbonate.
Concuoglu is aware that in the near future the water has to be re-injected in the soil, because of a recent implemented law on geothermal energy sources.

Aydın Chamber of Commerce – Mr. Mustafa Bastug (Head of Managing Board)

Ürgenpaşa Caddesi 13

Aydın

The region of Aydin is an important agricultural area in Western Turkey. The soil and climate are suitable for strawberries, lettuce, aubergine, etc. Besides that there are important economic activities in tourism, the university in Aydin has 20,000 students registered and the location close to Izmir, Istanbul and Antalya provide the region its important function to industry and distribution. Aydin has a great number of major geothermal area and hot water springs. The potentials of geothermal energy are far from fully utilised; there are great opportunities for greenhouse heating and district heating.

There was also a representative of the Provincial Directorate of the Ministry of Agriculture of Aydin. This ministry intents to play a stimulating role in the development of the application of geothermal energy for horticulture. Aydin represents the most promising geothermal energy area in Turkey. Actually 806 greenhouse farms cover 214 ha. The average size of greenhouse farm (0,25 ha) shows that further development is necessary. With the option of geothermal energy, further development of year round production systems can be realized. This will increase the production level and probably 80% of the yield will be suitable for export. Investing in geothermal energy will lead to a reconstruction of the greenhouse horticultural sector in Aydin and will have positive effects on the export potentials.
A rough estimation is that geothermal energy will lead to a 30% reduction of the energy costs. Moreover geothermal energy is more sustainable than fossil fuels.

Mege Geothermal Elektrik Santrali

Aydin

The Mege Geothermal Electric Company of Aydin has a capacity of maximal 8.5 Megawatt (electric) produced by geothermal energy and operates now for 2.5 year. The geothermal well (1300m depth with a pressure of 10 bar) has a flow of 500 ton per hour and the average temperature is 170°C. The return water with a temperature of 85°C is re-injected. The water also contains CO_2 (7 tons per hour). The purified CO_2 is sold to the Coca Cola Company in Izmir.
The initial investment in this electric plant amounts to $ 20 million.
The soil with the geothermal well was bought 10 years ago. At that time the price of the license to produce geothermal energy was about $ 100,000. The current market value is estimated at $ 5 million.
Further investments are necessary and provide opportunities for business development. With the energy that's still in the re-injected water (having a temperature of 85°C) ca. 30 ha of greenhouse area could be supplied. This amount of area is in property of the Electric Company. Besides that, this area also has a irrigation well at a depth of 100-150 m.

The Electric company is also acting as an investment company and aims to invest in greenhouse production without any responsibility for management or production. There are negotiations going on with some investors in greenhouse production who focus on the greenhouse production but till so far no contracts are made up.
For that reason partnership with Dutch experienced producers is requested.

A second power plant of 10 Megawatt will be taken in production in 2010. In that case some 50 ha of greenhouse area could be served with the reject heat of the geothermal energy. The second well contains also CO_2 (ca. 10 tons per hour), which – after purification - could be supplied to the greenhouse farms.

Izmir Chamber of Commerce
Ataturk Caddesi 126
35210 Pasaport- ***Izmir***
Izmir Economic University – Mr. Prof. Dr. Cemali Dincer (Vice Rector)
Sakarya Caddesi 156
35330 Balcova - ***Izmir***

The visit to the Izmir Economic University has had the focus of the activities of the 2g@there program. Geothermal energy wasn't a topic in that visit.
The Izmir Economic University is focusing its attention with respect to horticulture especially on the trade chains and the food processing. Growth and breeding of plants, and greenhouse construction and climate management technology are expected to attract too small a group of potential students.

Mineral Research and Exploration General Directorate – Mr. Hayrullah Dağıstan (Head of Department Energy Raw Materials Research and Exploration)
Telephone number (0312 2879177)
Internet: www.mta.gov.tr
Eskişehir Yolu 7. km
*06520- Balgat-****Ankara***

Mr. Dağıstan gave an overview of the activities of the Mineral Research and Exploration General Directorate (MTA) with regard to the geothermal energy areas in Turkey. One of the activities is the search for new fields and to determine and/or estimate the specifications of those fields (well depth, reservoir, flow rate, pressure, temperature, potential capacity, etc.).
At the moment Turkey has 187 geothermal fields with water above 40°C. The last three years 15 new fields have been added to the list of geothermal fields; more or less five new fields per year. The capacity of MTA is at the moment the limiting factor in the exploration of new fields. In principle any company may explore for new geothermal fields.

As a consequence of the recent ratified Law on geothermal resources and mineral water 34 geothermal fields will be tendered by the MTA in the period between 13 October 2008 and the first quarter of 2009. The other existing fields are in production or the license is already being issued.

Geothermal potentials in Turkey

In March 2008 mr. Dağıstan has given a presentation on the WIREC 2008 about recent geothermal applications in Turkey and projections for the year 2013. The most important issues are mentioned below.

- 187 geothermal fields with geothermal fluid more than 40°C temperature
- Fields with high temperatures exist mostly in western Turkey; low and moderate temperature sources exist in Middle- and Eastern-Anatolia and along North Anatolian Fault Zone
- Main uses are: space heating, domestic hot water supply, greenhouse heating, swimming and balneology, industrial processes. A few geothermal wells are used for electricity generation
- Currently most applications concern district heating.
- Geothermal greenhouse heating application:

- First application started in 1973 with 2000 m2 in Denizli-Kizildere:
- In recent years rapid increase in geothermal greenhouse heating applications. Major greenhouse applications are located in the Aegean region (Dikili, Balcova and Simav).
- Existing situation (2007): 11 geothermal applications of about 120 hectare with an estimated power of 232 MWt
- The projection for 2013 is ca. 352 hectare with 680 MWt (estimated power). The major extension of geothermal greenhouse heating will probably take place on the existing greenhouse areas with geothermal energy sources (162 ha and 315 MWt). In 2013 also 5 new applications of geothermal greenhouse heating is expected on an area of 70 ha and a capacity of 133 MWt.
- The additional investments required to fulfill to targets until 2013 are estimated on $ 200 million ($ 570 thousand per hectare greenhouses or $ 300 thousand per MWt).

Law on geothermal resources and natural mineral water (Law no. 5686; date of approval 3/6/2008)

Mr. Dağıstan provides us with the English version of this law (the full version is cited in Appendix 3). In short the main elements of the law are mentioned below.

- Chapter One: General Provisions Purpose

- Definitions: Ministry: the Ministry of Energy and Natural Resources; MTA: general Directorate of Mineral Research and Exploration; MIGEM: general Directorate of Mineral Works and Administration: Special Provincial Administrations.
- The purpose of this law is to set forth the procedures and principles regarding effective exploration, research, development, production of geothermal and natural mineral water resources, holding rights on these resources and devolution of the rights, economic utilization of the resources in a compatible way to the environment, and abandonment of these resources.
- Geothermal water resources and mineral waters are under the authority and possession of the State and are not subject to the property of land where they are found. To perform the activities which are related to the water resources, a License must be obtained according to this Law. The rights about geothermal water resources are endowed to the citizens of the Republic of Turkey .., to companies with legal qualities .., to public economic enterprises and establishments … and to other public institutions, establishments and managements.

- Chapter Two: Licenses

- Exploration license
  The exploration license is given for the purpose of performing water resource exploration activities in an area with defined borders. The exploration license applications are made by indicating the name and coordinates of an area with the exploration project to the management by the owner of the request. The exploration license covers a period of three years and, if needed, can be extended for another year. During the exploration period, only test-purposed production can be made, on the condition that the environment is not polluted.
- Business license
  The business license is given to the production and assessment of the fluid in a specific area. A business license can be obtained if the owner of the exploration license makes an application to the management within the exploration license period. To initiate the business activity, the business license owners are responsible for taking the required permissions from the related institutions. If the business license owner does not initiate business activity the business license is brought to bidding by the management. The business license will be given to the interested individual who makes the offer with the highest income to the management. The business license period is thirty years. If the license owner makes a request at the end of this period the license can be extended for ten-year periods.

- Chapter Three: Common Provisions Supervision of activities

- Activities
  Every year the activities are supervised by the management. Also the MTA can make the supervision. The license owner makes a payment of 1000 YTL to the MTA.
- Transfer, register, tender, charge, collateral and contribution for the administration
  The exploration and business licenses can be transferred. The administration is obliged to register particularities involving rights of transfer, confiscation, deposition, and mortgage or expiration related to the resource.
  The administration will tender exploration and business licenses if those licenses have been negatived, abdicated or curtailed by any reason. The tender announcement will be published in the Official Gazette.
  The charge for a exploration license for geothermal resources is 1000 YTL. For a business license the charge is 4000 YTL.
  Depending on the license phase a license collateral is accounted equal to 1% of the license charge. The minimum collateral is 15,000 YTL.
  An administration contribution of 1% of gross income of the facilities that use the fluid directly or indirectly will be paid to the administration every year. One fifth of he amount is passed to the municipality or village corporate body where resource is present.
- Usufruct and nationalization
  The owner of the exploration license or the business license can claim his/her rights to usufruct respectively usufruct and nationalization by applying to the administration, when he/she can not come to an agreement with the owner of the immovable in the area of search actions or of operating activities.
  Companies that make geothermal resource distribution and production shall be considered as industrial and waste treatment organizations. They shall benefit from first of all electric tariffs and all the other incentives and rights that are granted to the industrial organizations and waste treatment organizations.
- Protection of resource reservoir
  Before actions for operation are carried out a protection area study of the resource by the license holder is obligatory. Otherwise actions of the license holder shall be stopped.

- Chapter Four: Miscellaneous Provisions Rights related to services of the MTA

- MTA carries out its research of geothermal and natural mineral water resources upon a license received pursuant to the provisions of this Law. In case the MTA identifies existence of resource in areas for which it has received license to research, such areas are tendered by the MTA. The successful bidder obtains an exploitation license.
- MTA can carry out any kind of scientific and technical survey anywhere, including viable license areas without requirements of license.
- Besides participating in the tendering procedures of the MTA, according to the 'Law On Geothermal Resources And Natural Mineral Water', individuals can apply for an exploration license and business license directly at local authorities.

- Chapter Five: Interim and final provisions, enforcement and execution

- Provisional articles are described with respect to the above mentioned topics.

Tender program by the MTA

According the Law on geothermal resources and natural mineral water, the MTA is competent to coordinate the tender for new fields with geothermal resources. The first tender will be carried out in the fourth quarter of 2008. The tender will be done in three steps for three different target groups: 1) power stations, 2) greenhouse heating and 3) thermal tourism.

In the first step six geothermal fields will be tendered for electricity generation. The fields are located in the regions of Aydin (4) and Manisa (2). The highest bidder will obtain the business license. Beside that, the business license owner has to apply for the necessary permissions of related institutions (governments).
The MTA has issued an overview of the new fields containing figures about well name, well depth, depth reservoir, flow rate, dynamic and static temperature, reservoir temperature and the potential capacity. MTA labels the mentioned potential capacity as a conservative estimation and could be seen as the minimum capacity of the well. However no guarantee can be given for the potential capacity.
In some cases, fields are also containing bicarbonate, which offer possibilities to gain carbon dioxide (by purification) and to sell it to interested parties.
The other 28 geothermal fields that in the next two steps will be tendered for greenhouse heating and thermal tourism are not known at the moment. This list is being asked for at the MTA.

Instanbul Technical University
Institute of Energy – Mr. Prof. Dr. Abdurrahman Satman (Director)

Istanbul Teknik Universitesi,
34469 Maslak Kampusu, ***Istanbul***

Mr. Satman is director of the Institute of Energy and expert on the field of geothermal energy resources. Below some aspects related to geothermal energy are presented.

Tender program of geothermal energy sources

Giving the lack of experience by all involved parties, the tender program that is going to be carried out in a very short time is a risky operation. There is only a very short time for potential bidders to make a good estimation of the revenues that can be expected from each of the wells in the tender program.
Moreover, there is only very little information on the long term behavior of the temperatures and pressure head of the wells since up till now geothermal energy has only be used to a small extent.
From physical point of view one can expect that the temperature deep down surely will drop when substantial amounts of heat are extracted. Also, the mutual independency of the behaviour of adjacent wells can be questioned, even if the interspacing seems to be large. We have only a faint idea of the deep down hot water flows that bring the heat to the wells.

Sustainability of geothermal fields

With respect to sustainability there is still insufficient information about the performance of the geothermal fields on the long term. Its is to be expected in the future that the temperature will show a slow decrease when substantial amounts of heat are extracted. Especially for power generation, such a decrement of temperature will affect the performance significantly. Greenhouse or district heating, operating at lower temperature levels are less affected by a temperature decrease. Moreover, since these types of geothermal heat application rather have a seasonal than a year round character, the risk of temperature degradation is less.

Geothermal energy for greenhouse heating

First project was in Dikili. This is a small geothermal field, which was originally meant for district heating. The mayor of Dikili possessed the rights (licenses) of two geothermal fields. When the district heating project was cancelled, the rights of the geothermal fields were sold to greenhouse entrepeneurs (e.g. Agrobay).

Due to the fact that the demand for electricity is growing rapidly and there is a shortage of substitute electricity in Turkey, the Turkish government stimulates the application of geothermal energy for electricity production. In the coming years an extra electricity production with geothermal heat is to be expected of 75-80 MW_e. The potential

capacity of electricity production with geothermal heat is about 450 MW_e. This is lower than the projections of MTA for the year 2013 (= 565 MW_e).
The current power plants however only use half of the geothermal heat, because the re-injection temperature is (far) above 65 °C. This reject hot water can be used for greenhouse heating and can add substantial value to both horticulture and a geothermal power plant.
It is advisable for growers to investigate the possibilities of settlement near geothermal power plants and start negotiations with the owners of these power plants. From that opinion Mr. Satman suggests the power plant company and the greenhouse firms to set up an integral approach how to exploit the geothermal fields in the most effective and economic way. Especially the greenhouse sector can profit from such an integral approach.

Appendix III.
Law on geothermal resources and natural mineral water

1) **Law No. 5686 Date of Approval: 3/6/2007**

CHAPTER ONE

General Provisions Purpose

ARTICLE 1 - (1) The purpose of this law is to set forth the procedures and principles regarding effective exploration, research, development, production and protection of geothermal and natural mineral water resources, holding rights on these resources and devolution of the rights, economic utilization of the resources in a compatible way to the environment, and abandonment of these resources.

Scope

ARTICLE 2 - (1) This law encompasses the procedures, principles, and sanctions on holding and devolving the rights on the resources; abandonment of the resources: tendering, terminating, and supervising resource utilization; and protection of the resource and accumulation reservoir during exploration and operation periods of detected or to be detected geothermal and natural mineral water resources and geothermal gases.

Definitions

ARTICLE 3 - (1) As used in this law;

2) The Ministry refers to: The Ministry of Energy and Natural Resources.

3) MTA: General Directorate of Mineral Research and Exploration.

4) MIGEM: The General Directorate of Mining Affairs.

5) Administration: Special Provincial Administrations.

6) Resource: areas where geothermal fluid or natural mineral water, gas or all are extracted naturally, through drilling or wells.

7) Geothermal Resource: means the natural water, steam and gases which may include melted substances and gases with temperature permanently higher than the regional atmospheric average due to the natural heat in the earth crust, and the areas where water, steam and gases obtained from crust or hot dry rocks through regulated human methods.

8) Natural Mineral Water: cold and hot natural water also known as thermal spring, medicinal spring or similar which is used for healing, originating naturally in proper geological conditions and in different depths of the crust, emerging from one or more resource naturally or being extracted, and defined by its mineral content and other components.

9) Geothermal area: an area of which borders are detected through scientific and technical studies, having geothermal resource and natural mineral waters within its limits.

10) Geothermal system: system providing geothermal area: including feeding zone, fluid, heat zone, reservoir and/or zone, seal rock or the whole discharge zone, in which, geothermal resources and/or natural mineral water emerges or extracted, having its unique geological structure, hydrological and chemical characteristics.

11) Geothermal reservoir: semi-open or closed hot water and/or steam extraction area which is fed extrinsically in various ways and which has a geochemical integrity and natural balance in terms of heat.

12) Drilling: digging and opening a pit with geological investigation from the surface of the earth to the source in the required depth and diameter by utilizing scientific methods and proper tools for the purpose of exploring, producing, reinjecting the geothermal fluids after use, observing or testing the reservoir; and digging a well to inject fluid for developing a geothermal reservoir.

13) Fluid: Water, gas and vapor obtained from the water sources.

14) Catchment: The procedure of accumulating the fluid in specially built pools, galleries and/or wells'1 before utilization, preventing pollution from the time it arrives into the earth from the reservoir naturally or using scientific methods and proper equipment, so that the fluid can be protected and used more healthy way.

15) Protection zone: the zones of the resource and the geothermal system those resources exist; requiring measures to be taken specified according to geological, hydrological structure of the zone, climate conditions, ground category and types, limit of drainage zone, settlement areas around the resource and the well, industrial facilities, and topographical structure of the area for the purpose of protecting it from external factors which may cause its destruction, pollution, and losing its sustainable characteristic, that the activities performed in it are subject to supervision, and that construction and field usage areas may be restricted when necessary.

16) Blockaded zone: the areas closed for the operation by the ones besides the one having the license for operation in order to prevent the production activity from a geothermal resource from being affected.

17) Injection: Sending the fluids to geological formations with artificial methods,

18) Reinjection: After utilizing them with artificial methods, sending/pumping the complete or remaining parts of the produced geothermal fluids to the geological formations where they were produced.

19) Discharge: After the utilization of the geothermal fluid, sending the complete or the un-reinjected part to some other recipient setting in a way not to create environmental pollution,

20) Testing: studies performed to determine physical and chemical parameters in order to develop program for reservoir production, management, and monitoring.

21) Secure Efficiency: maximum amount of fluid that can be produced from the same reservoir in unit time so that the geothermal system and balance of the reservoir is not destructed,

22) License: the document given for the permission to detect and operate activities in an area with specified limits/borders.

23) Project: a document regulating the activities to utilize the resource, prepared in accordance with specific procedures and principles, stating the information on the timetable for starting, developing, and ending the activities during exploration and operation.

24) Exploration: activities started with geological research, supported with geochemical and geophysical studies for the purpose of obtaining fluid from the geothermal system, including other test activities for the production and the drilling opened with geological trace in compliance with the purpose and the technique in location and locations determined through analysis of all the data collected from the other studies.

25) Exploration license: The project-based authorization document which is given for the purpose of performing water resource exploration activities in an area with defined borders.

26) Operation: The whole of activities that are indicated in the project which include the production, usage, reinjection, injection, discharge of the water resource that is obtained as an outcome of the exploration activities, and the drilling studies which are directed to these activities,

27) Business License: The project-based authorization document which is given for the production and assessment of the fluid in a specific area.

28) Activity: The procedures about the exploration, development, administration and abandonment of geothermal water sources, and the usage of geothermal and natural mineral waters.

29) Activity report: The report which is prepared annually during the license period according to the criteria that are determined by legislation, and which provides the communication of the developments about the activities to the management and the MTA,

30) Leasing contracts: The contracts which provide the leasing of the rights that are related to the usage areas, which are based on the business license, to other parties,

31) Force majeure: Flood, fire, earthquake, collapse, landslide, state of war and other circumstances that are stated in the regulation,

32) Unexpected Events: Unexpected physical and chemical changes in geological and water resource conditions and the situations when the required permissions which should be taken from other institutions according to the related legislation cannot be taken,

33) Collateral: the insurance given to the administration in the form of cash, bank or private finance performance bonds, or state bonds to be used under circumstances affecting life and property of the public during the activities for the utilization of the resource, where necessary precautions are not taken by the license holder.

34) Gross revenue: the total annual endorsement of the enterprise, including the goods and service costs and renting on interest accrued to the enterprise.

Property and license

ARTICLE 4- (1) Geothermal water sources and natural mineral waters are under the authority and possession of the State and are not subject to the property of land where they are found. To perform the activities which are related to the water sources, a License must be obtained according to this Law.

2) The rights about geothermal water resources and natural mineral waters are endowed to the citizens of the Republic of Turkey who are competent to benefit from civil rights, to the companies with legal qualities which are established according to the laws of the Republic of Turkey in the status of which the particularity of performing activities about geothermal water sources and natural mineral waters take place, to the public economic enterprises and establishments that have authority about this particularity, and other public institutions, establishments and managements with their dependent partnerships and participations. The rights concerning geothermal water resources and natural mineral waters are given to the name of real or legal individuals.

3) The rights concerning geothermal water resources and natural mineral waters are transferred through inheritance. With a trust deed containing all of the inheritors' permission, these rights can be transferred to one of the inheritors who have the qualities indicated in the second paragraph, or to a third party. If the inheritors do not act together, with the application of one of the inheritors, the court decides to assign this right to the most competent inheritor, or if this is not possible as well, it reaches the decision of selling the license. The court solves this matter with a simple way of judgment. If the lawsuit is not possible, the licenses which are not transferred within six months are annulled. The regulation decides how devolution and transfer procedures are going to take place.

CHAPTER TWO

Licenses

Exploration License

ARTICLE 5- (1) The exploration license applications are made by indicating the name and the coordinates of 1/25000 scaled sheet, which does not exceed five thousand hectares, with the exploration project to the management by the owner of the request. Priority right forms the basis in the applications. In the case where there is more than one request for the same place, the projects are inspected, and the request of the project owner which proposes the fastest and the biggest investment is preferred.

2) The management communicates the information about the application area to MIGEM. If the area for which the application is made with other applications, MIGEM informs the management that it can give 'exploration license' to the area which is left outside the removed intersecting parts. The management informs MIGEM about the given license to be recorded with its coordinates.

3) The exploration license covers a period of three years. On the condition that the activities develop positively and additional studies are needed, the license is extended for another year if the management approves the revised project. MIGEM is informed about the extension. The request for the extension of the exploration license period is made to the management before the end of the license period.

4) Throughout the exploration period, only test-purposed production can be made within the knowledge of the management, on the condition that the environment is not polluted.

5) In the case of the exploration and business activities that incorporate more than one province, the applications are made to the provincial management where the area is bigger and the procedures are communicated to the smaller provincial management.

Business License

ARTICLE 6- (1) If the owner of the exploration license makes an application to the management for a business license until the evening of the last day of the exploration license period, the 'business license' will be given and it will be informed to MIGEM with the proved blockaded area, if there is any.

2) To initiate the business activity, the business license owners are responsible for taking the required permissions from the related institutions.

3) If the business license owner does not initiate business within the time period indicated in his project, or in the case when his business license is cancelled for any reason, the assurance is recorded as annuity, and the area is brought to bidding by the management. The business license will be given to the interested individual among the interested ones that take part in bidding, who makes the offer with the highest income to the management, and this is communicated to MIGEM.

4) The renovation of any well that takes place in the project, the increase in their numbers and capacities, injection, reinjection, all production-purposed drilling activities and other changes in the project and revisions cannot be made without taking the consent of the management. The management, if necessary, can require an assessment from the MTA after paying its price.

5) The business license period is thirty years. By the end of the period, if the license owner makes a request, the license is extended for ten-year periods. The period extensions are communicated to MIGEM.

6) For geothermal and natural mineral waters emerging naturally, the direct business requests after the catchments are attached to business license by the management, according to the clauses of this Law, and communicated to MIGEM.

Technical responsibility and activity report

ARTICLE 7- (1) Throughout the exploration and business license period, the activities must be continued under the responsibility of an engineer from the engineering branches which are related to the activities. If the activities are performed without a technically responsible person, the license collateral shall be deemed as annuity, and the activities are terminated.

2) Technically responsible person performs his duties and responsibilities by protecting the scientific and technical principles in the exploration of the water resources, its research, development and production. However, in natural mineral water facilities, any graduate from a related engineering department can act as the technically responsible person.

3) The annual exploration and business activity reports that are prepared by the technically responsible person or persons must be submitted in two copies by the owner of the license to the management until the end of the month of March of the subsequent year. One copy of the activity reports are transmitted to the MTA.

4) If the exploration and business activity reports are not submitted to the management before the deadline, an additional period of two months will be provided by deeming its collateral as annuity, and the assurance is doubled within two months. If the activity report is not submitted by the end of this period, the license shall be cancelled and MIGEM shall be informed.

Force majeure and unexpected events

ARTICLE 8- (1) The license holder, in the case of a force majeure or an unexpected event, under the condition that he provides a justification and period, may contact the administration and demand that the delay time to be added into the duration of the license and to be relieved from his responsibilities during that period. The date of such a demand application shall be accepted as the start date of force majeure.

5) Within latest three months, upon the elimination of the force majeure state or unexpected situations, the license owner has to start operating. Unless operation is initiated within this time frame, the collateral shall be deemed as annuity and another period of three months will be granted so that the license holder can operate. If the collateral is not deposited or operation does not start at the end of this additional duration yet again, then the license shall be cancelled.

CHAPTER THREE

Common Provisions Supervision of activities

ARTICLE 9- (1) Every year the activities are supervised by the management. If the management requires, the MTA can also make the supervision, when needed. The supervisions are made by taking the particularities in Article 14 and the principles in other articles into consideration. For the supervisions, the license owner makes a payment of 1000 YTL to the MTA. This amount is increased by the MTA according to the annual PPI rate.

2) Outside the locus of civil service post, a civil servant who is charged by MTA and who is related with the issue and assists, not associating with article 50 of Law No. 6245 on Travel Allowance dated 10 February 1954, shall be paid every year twice as much as daily travel allowance amount determined by Budget Law and according to general provisions of the law No. 6245 on Travel Allowance. Daily amount which is paid within the context of this article shall not be curtailed under any name.

3) If necessary, MTA may need the participation of other related ministry, public institutions and organizations for the inspections and examinations to be made.

Transfer, register, tender, charge, collateral and contribution for the administration

ARTICLE 10- (1) Basic principles related to transfer, register, tender, charge, collateral and contribution for the administration are as follows:

a) Transfer: Licenses of searching and operating can be transferred.

b) Register: The administration is obliged to register particularities involving rights of transfer, confiscation, deposition and mortgage or expiration related to the resource. Limits of license, coordinates of wells, parameters of fluid, transfer, precautionary confiscation, temporary injunction, information related to mortgage, rent related to usage of fluid and similar contracts with expiration of rights shall be registered. Rights shall bear provision and result only after they are registered. Persons who are concerned might claim their register to be shown before one of the register officers of administration. Register is declared and it can not be claimed that records in the register of the resource is not known. Contracts made related to the rights can not be alleged against third parties unless they are registered by the administration.

c) Tender: Licenses which have been negatived, abdicated or curtailed by any reason shall be made available for exploration and operation by the administration using tendering. The tender announcement shall be published in the Official Gazette. If there is not any application during the period of the tender, areas of license shall be informed to MIGEM by administration and shall become open to applications of exploration and operation and there shall be no need to any other process.

d) Charge: 1000 (a thousand) Turkish liras shall be charged for the exploration license for geothermal resources and 500 Turkish Liras shall be charged for exploration license for natural mineral water resources. For operating licenses this charge amount is four times as much as above.

e) Collateral: Depending on the license phase, an amount of license collateral equal to 1% of license charge shall be taken per hectare. Council of Ministers is authorized to increase or decrease this rate by 50%. However collateral shall not be lower than 15.000 Turkish liras. The minimum amount of collateral and charges shall be increased every year according to revaluation rates determined by the Ministry of Finance. Operating license collaterals which are previously taken in accordance with this article shall be updated by increasing according to revaluation rates determined by the Ministry of Finance quinquennially. The collaterals which must be completed and renewed in accordance with this law shall be charged at the rate of updated collateral.

f) Contribution for the administration: An administration contribution of 1% of gross income of the facilities that use the fluid directly or indirectly shall be paid to the administration until the end of June each year. One fifth of the amount collected shall be paid to municipality or village corporate body where resource is present in a month by the administration.

2) Rightful owner shall be considered to abdicate his/her claim if charge and collateral is not deposited in 15 days after he/she is informed that his/her application is accepted.

Administrative sanctions

ARTICLE 11- (1) The activities should be carried out in accordance with the project. If it occurs that the license owner does something that is not stated in the project or does something without permission, the collateral shall be deemed as annuity and the activities shall be stopped and the collateral shall be increased three times as much and made to be completed in a month. If the same action is repeated, the collateral shall be deemed as annuity and the license shall be canceled.

2) If it occurs that the license owner begins to operate before the study of resource protection area or does not abide by the precautions envisaged in the protection area study, activity shall be stopped and the collateral shall be deemed as annuity. The license owner shall be demanded to take necessary precautions and to complete the collateral in six months. Activities shall be stopped if the collateral is not given and precautions are not taken at the end of six months.

3) If the contribution for the administration is not paid in the required period, the collateral shall be deemed as annuity and an additional period of six months shall be granted. Actions shall be stopped if administration contribution is not deposited and the collateral is not completed during this period.

4) If it occurs that there is any action without a license, activities shall be stopped. According to law No. 5302 on Special Provincial Administration dated 22 Feb. 2005, 50.000 Turkish Liras of administrative fine shall be accrued by the administration.

5) In the event that urgent precautions are necessary for the protection of resource and reservoir and for the prevention of environmental pollution, precautions shall be taken by the administration. All the expenses incurred for this reason shall be collected from the responsible party by the administration according to provisions of Law

No. 6183 on Collection Procedure of Public Receivables, dated 21 July 1953.

Usufruct and nationalization

ARTICLE 12- (1) If the owner of search license cannot come to an agreement with the owner of immovable of private ownership in the area of search actions, he/she can claim his/her right to usufruct.

2) During the period of operating license if a settlement can not be arranged with the owner of immovable as for the places such as drilling site, transmission line and catchment, owner of the license can claim the right to nationalization and usufruct by applying to the administration. If claim is found appropriate after it is examined and evaluated, decision of public interest shall be taken.

3) Proceedings of usufruct and nationalization shall be conducted in compliance with the provisions of Nationalization Law no. 2942 of 4 November 1983. Usufruct and nationalization costs and expenses shall be paid by the owner of license.

4) Nationalized immovable shall be registered to land registry in the name of the administration and allocated in the name of the license owner during the period that activities are continued.

5) If it is detected by the administration that nationalized immovable is no more necessary for the activities, provided that current market value determined in accordance with the procedures and basic principles envisaged by Nationalization Law is paid, the matter of returning the nationalized place to its previous owner shall be notified to the license owner and the previous owner of the immovable. If the previous owner of the immovable does not want to take it back in six months, immovable shall be left to the administration.

6) Annotations that have been put to the land registry shall be deleted with no additional need to court decision.

7) After the enforcement date of this law, rent, mesne profits shall not be taken for the activities in the places of private ownership of treasury and places under the adjudication and management of the State.

8) Companies that make geothermal resource distribution and production shall be considered as industrial and waste treatment organizations. In accordance with this assessment they shall benefit from first of all electric tariffs and all the other incentives and rights that are granted to the industrial organizations and waste treatment organizations.

Seizure, confiscation, interim injunction and mortgage imposition

ARTICLE 13- (1) Integral parts directed to production of the resource such as wells, all kinds of facilities, equipment, water carriage lines and systems, devices and other one-year operating material required for the licensed area operation cannot be confiscated and an injunction cannot be granted on them individually; however they can be confiscated and injunction can be imposed on them, as a whole. After an injunction is granted as a whole and executionary selling is decided, the actions of the enterprise cannot be intervened.

2) Mortgage imposition on the enterprise license is possible, in accordance with the related provisions of the Turkish Civil Code No. 4721 of 22 November 2001; however, the period of license shall not be exceeded. If there are changes in the areas of enterprise license on which mortgage is formed, present mortgage remains upon the new license, without a need for any proceeding.

3) In the event that enterprise license expires, mortgage remains upon the facility, vehicle, device and material that belong to the license holder, except wells and facilities that have been made to protect them.

Protection of resource reservoir

ARTICLE 14- (1) In actions subjected to this law, protection of geothermal system, no waste of the resource and protection of environment are basic principles and before the actions for operation, protection area study of the resource by the license holder is obligatory. Otherwise, actions shall be stopped and the license holder shall be given appropriate time to determine the protection areas. At the end of this period, if protection areas are not determined, provisions of Article 1 1 shall apply.

2) Reports of protection area study, after taking the opinion of MTA, shall be approved by the administration. Limitations and conditions, envisaged in the study of resource protection areas related to land use and structuring, form the base for zone plan. General principles related to precautions to be taken in the resource protection areas, shall be determined by regulation.

3) During the inspections made by MTA, if it is identified that actions are not conducted in compliance with the precautions, actions shall be terminated by the administration. Precautions to be taken shall be determined by MTA and informed to the administration. It is the responsibility of administration to take precautions and /or to have them taken. Maximal period of time for precautions to be taken is one year. If the envisaged precautions are not fulfilled, license shall be revoked.

4) The license holder might discharge the fluid, which is generated after the use; meanwhile, the holder shall take environmental limits into consideration. According to the environmental limits, if the content of the fluid does not allow for discharge, he/she is obliged to reinject. However, if it is approved by MTA that reinjection is not made because of the physical and chemical features of the formation, the discharge shall be made after environmental protection precautions are taken.

5) For the separate water spring and natural mineral water enterprises out of the integrated geothermal resource utilization area, the conditions of reinjection and injection may not be sought. In this case, the administration shall make a decision, in accordance with the opinion of the Ministry of Environment and Forestry.

Abandonment and transfer of facilities

ARTICLE 15- (1) The search and operating license holder might claim abandonment of all or some part of the license area. In this case, the administration shall accept the claim of abandonment following the identification of the fulfillment of necessary safety precautions and landscaping.

2) In the event that exploration and operating licenses expire on account of termination, cancellation, abandonment or expiration of the time period, the wells and facilities made to protect the wells, shall be transferred to the administration under the condition that necessary well safety precautions have been taken and no compensation shall be given to the holder. Other facilities, vehicles, tools and materials belong to the license holder. Assets passed to the administration by this way shall be sold by tender and necessary licensing shall be done.

CHAPTER FOUR

Miscellaneous Provisions Rights related to services of the General Directorate of Mineral Research and Exploration

ARTICLE 16- (1) MTA carries out its research of geothermal and natural mineral water resources upon a license received pursuant to the provisions of this Law, being exempt from the license fee and compensation. In case the MTA identifies existence of resource in areas for which it has received license for research, such areas are tendered by the MTA and the successful bidder is delivered an exploitation license. Costs incurred by the MTA are received on the tender price and then the remaining amount is shared on equal footing by the MTA and the administration.

2) MTA can carry out any kind of scientific and technical survey anywhere, including the viable license areas, without requirement of license.

Aspects related to culture and tourism conservation and development sites and tourism centers

ARTICLE 17- (1) In culture and tourism conservation and development sites and tourism centers, as declared pursuant to the Law on Promotion of Tourism;

a) Regarding thermal-purpose exploitation licenses to be issued in line with this Law, requirements relating to other usages can be met only after investment fields identified with construction plans and the amount of resources required by the capacity of enterprises are provided. In areas of usage, operational permit cannot be granted without any construction plan.

b) Price of the usage of geothermal water of tourism-certified facilities is determined according to the amount of water used.

c) Prior opinion of the Ministry of Culture and Tourism is sought by the administration for activities.

3) In areas where there is fluid other than those for production of energy and heating, thermal tourism-purpose is priority in terms of usage of the area.

4) Concerning the companies to be established within the scope of this article by municipalities. Article 27 of the Law No. 4046 on Privatization Practices is not applied, the opinion of the Ministry of Interior is sought.

5) All procedures and principles related to the implementation of this article are identified in line with the regulation to be issued upon approval of the Ministry of Culture and Tourism.

ARTICLE 18- (1) The third paragraph of Article 47 of the Mining Law No. 3213 dated 4/6/1985 has been amended to read as follows.

'General Directorate of Mineral Research and Exploration gains the right of discovery, pursuant to Article 15, for the mines that it has searched and found, in line with the provisions of this Law. These licenses, transferred to the General Directorate till the end of the licensing period of exploration, are tendered in line with Article 30. 50% of the proceeds acquired as a result of the tender and it is charged to the MTA's account as resource income.'

ARTICLE 19- (1) MTA can carry out exploration, research and development as well as scientific and technical survey on geothermal and natural mineral waters in the country or abroad, with local and foreign public or private legal persons. At least 20% share is received from operating earnings, according to the ratio to be determined, in line with the agreement concluded with the relevant entity. Procedures and principles relating to implementation under this article are determined through a regulation to be issued by the Ministry.

Legislation

ARTICLE 20- (1) Procedures and principles relating to the implementation this Law, are determined through Regulations to be issued by the Ministry, within six months of the enforcement of this Law.

Abolished Provisions

ARTICLE 21- (1) This Law has abolished the Law No. 927 on the Abuse of Hot and Cold Mineral Waters and Establishment of Spas of 10/6/1926 and, Additional Article 1 of the Law No. 2634 on the Promotion of Tourism of 12/3/1982 along with the Obsolete Regulation on Minerals (Mulga Maadin Nizamnamesi) of 26 March 1322 and Article 50 of the Regulation on Minerals (Maadin Nizamnamesi) no. 1794 of 26/3/1931 and, and the provisions related to medicinal hot and cold mineral waters and spas for bathing of the Obsolete Law No. 4268 on Exploration and Exploitation of Minerals dated 17/6/1942.

CHAPTER FIVE

Interim and final provisions

PROVISIONAL ARTICLE 1- (1) Before enforcement date of this law; rights and liabilities granted according to the Obsolete Regulation on Minerals (Mulga Maadin Nizamnamesi) dated 26/3/1322, the Obsolete Law No. 4268 on Exploration and Exploitation of Minerals dated 17/6/1942. the Law No. 3154 on Organization and Duties of the Ministry of Energy and Natural Resources dated 19/2/1985, the Law No. 5177 (26/5/2004) on the Amendment of Mining Law and Some Laws, the Laws no. 927 and 2634 along with the Obsolete Law No. 6309 on Minerals dated 3/3/1954 pursuant to Decision of the Council of Ministers No. 83/6568 are executed in line with the following:

a) Adaptation of resources exploited or rented by Special Provincial Administrations is entrusted to special provincial administrations,

b) Adaptation of resources, licensed by Special Provincial Administrations for operating is adapted to license holders,

c) Adaptation of resources of which charge and dividend shares are transferred by the province is made on behalf of the assignee Municipality or village community.

d) Adaptation of resources exploited and/or rented by municipalities is made on behalf of the municipal corporation,

e) Adaptation of resources exploited by companies that are partners to municipalities and special provincial administrations is made on behalf of the companies,

f) Adaptation of exploitation rights granted with agreements and protocols concluded with public or private persons, municipality and special provincial administration before publication date of this Law by the MTA. is made on behalf of the relevant holder of the right, after identification of the area by the MTA,

g) Drinking waters, mineral waters, hot springs and spas for which an extension request has been made and which has been extended according to the provisional Article 5 of the Law no 5177 are adapted on behalf of the relevant holder of the right,

h) Resources exploited by the Electricity Generation Co. Inc. are adapted on behalf of the Electricity Generation Co. Inc. after identification of the field by the MTA.

And all the above-mentioned processes are executed by the administration. In case the Electricity Generation Co Inc. or Privatization Administration tenders this area to third parties, 50% of the tender is charged to the MTA as equity capital. Contract and operational conditions as well as acquired rights of the third parties are registered within adaptations.

2) Concerning operational privileged licenses, total duration cannot exceed ninety-nine years considering the time used in the past by the holder of the right.

3) Licenses that are adapted are declared to the MIGEM.

4) As of the enforcement date of this Law, licenses for which an extension request is made within its duration according to the Law No. 927 and new applications made to receive license pursuant to the additional article 4 of the Law no. 5177 are processed, concluded and licensed as appropriately by special provincial administrations according to the additional article 4 of the Law no. 5177 and no. 927, which are in force at the time of application; thus adaptation to this Law is carried out.

PROVISIONAL ARTICLE 2- (1) Holders of the rights acquired prior to enforcement of this law are liable to apply to the administration for conclusion of adaptation purposes within six months along with the existing data and documents pertaining to the resources concerned, accompanied by the information on the present facilities in the relevant area, their projects, license proving the ownership of these facilities, permit, privilege, contract, registry records and similar documents as well as the exploitation project and deposit receipts if any.

2) Regarding rights for which no adaptation request has been made within six months, the collateral is doubled and additional period of six months is granted. In case no application for adaptation is made within the extension period, no further action is taken with regards to the rights concerned.

3) No application is accepted for one year as of the enforcement date of the law. Applications made in the first week following this period are considered to have been made simultaneously and priority order is determined by drawing lot. Application charge in the sum of the minimum collateral amount is received from applications made in the first week.

4) The administration is obliged to declare to the MIGEM, the holder of the right, resource and area boundary coordinates, type of the resource, duration, ownership status and all other necessary information related to the resource licenses in the province and applications for which licensing is approved by MIGEM within three months of enforcement of this Law.

PROVISIONAL ARTICLE 3- (1) For resources and resource areas, transferred, rented or usage right is granted by the MTA through an agreement before enforcement of this Law to public or private legal persons, municipalities, special administrations with a duration ending as of the enforcement date of this law. or resources and/or resource areas identified by the MTA and registered and to be registered on behalf of the MTA. the administration gives a research license to the MTA and this is declared to the MIGEM. These license areas are tendered by the MTA. Research costs incurred by the MTA are deducted by tendering earnings and the remaining amount is shared between the MTA and the administration equally.

2) In case any one of the areas that have been registered or are to be registered on behalf of the MTA cannot be tendered due to any reason, half of the administration share is paid to the MTA.

PROVISIONAL ARTICLE 4- (1) In lieu of the 'Turkish Lira' mentioned in this Law. 'New Turkish Lira' is used as long as the provisions of the Law No. 5083 on the Currency of the Republic of Turkey dated 28/1 2004 stipulate that the money in circulation within the country (Turkey) is New Turkish Lira.

PROVISIONAL ARTICLE 5- (1) Among power plants using local coal fuel above 1000 MW to be set up by the companies which will be entitled to the right to use coal as a result of the coal allocation (royalty) tender to be held by the Electricity Generation Co. Inc., electricity generated by those entering into operation by the end of 2014 are purchased by companies having retail and wholesale license through bilateral agreements with duration of fifteen years, and provisions related to the electrical energy to be incurred are recorded on the license of these companies.

2) If there occurs a generation balance that is not agreed through bilateral agreement between the amount of electricity to be sold to retail and wholesale companies and the amount to be generated, the General Management of Turkish Electricity Trading And Contracting Inc. makes the procurement agreement.

3) In tenders of the coal allocation (royalty) to be held by the Electricity Generation Co. Inc. for construction of power plants using local coal fuel above 1000 MW; the royalty fee across years, electrical energy generation amounts across years for duration of fifteen years and electrical energy sale prices can be bidded by the wishing parties. Selection in this tender will be done within the scope of the principles to be identified in the specifications, as a result of a calculation based on addition of electricity procurement prices (obtained by multiplying annual generation amounts to be bidded with annual unit electricity sale prices) and the prices adjusted to the tendering date upon a pre-determined discount rate and valuation of the royalty price.

Enforcement

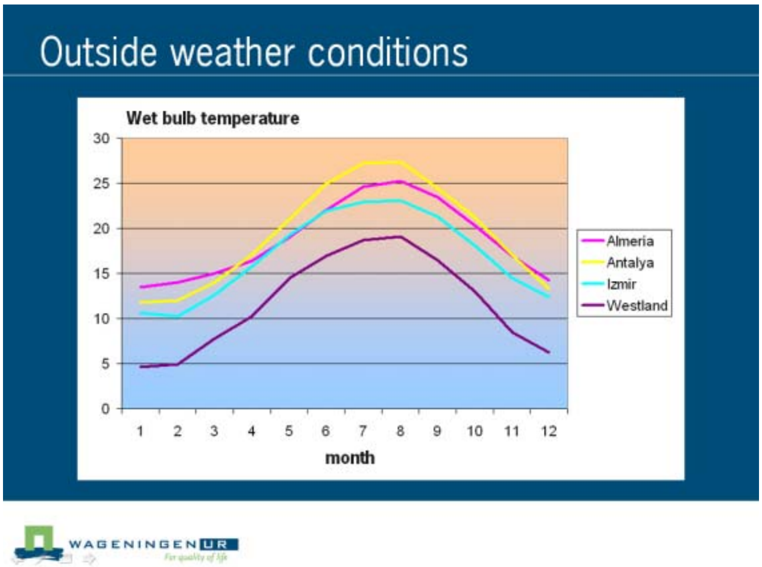
ARTICLE 22- (1) This Law becomes effective, on the day of its publication

Execution

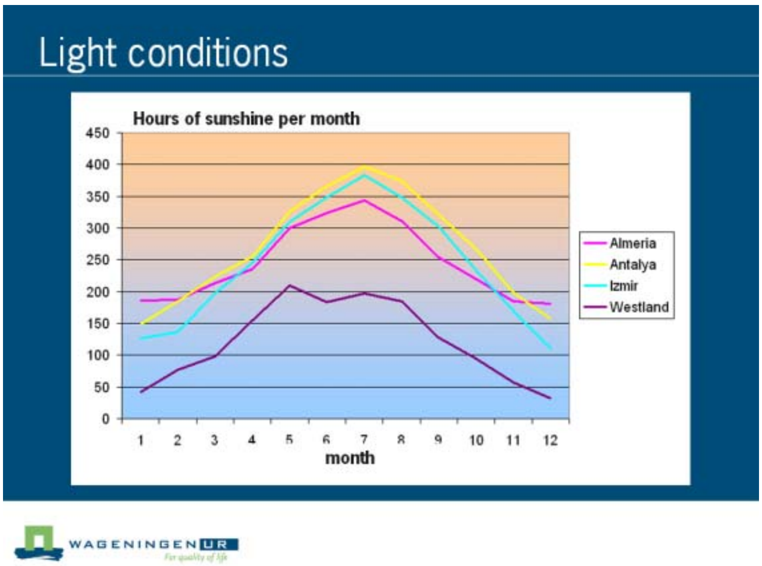
ARTICLE 23- (1) The provisions of this Law are executed by the Council of Ministers.

Appendix IV.
Presentation on geothermal perspectives for the participants of the 2g@there program

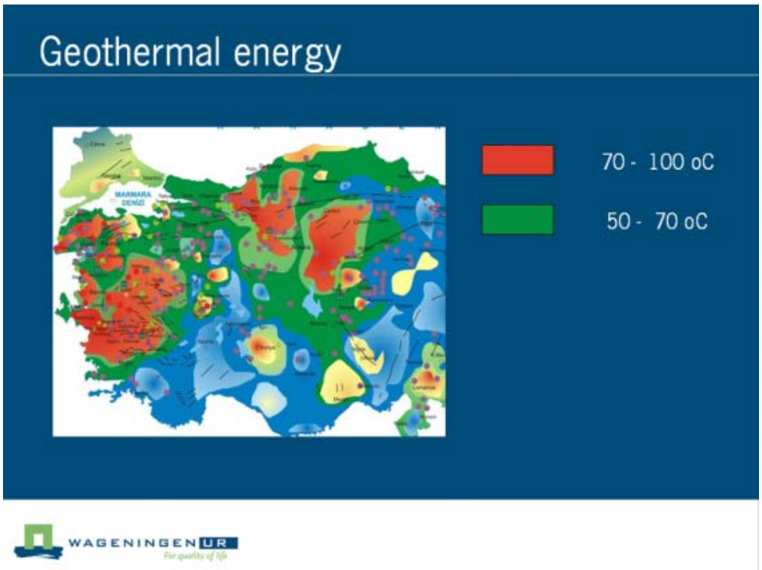
Marc Ruijs and Feije de Zwart visited the areas around Dikili and Aydin in September 2008. These regions have high potentials for geothermal heat (which will be described in more detail a few slides further). The area around Denizli is known to be favorable from literature. The area around Antalya is important for horticulture but has only very poor geothermal perspectives.
Besides describing the area's of interest the slide shows differences in country size between Turkey and the Netherlands.



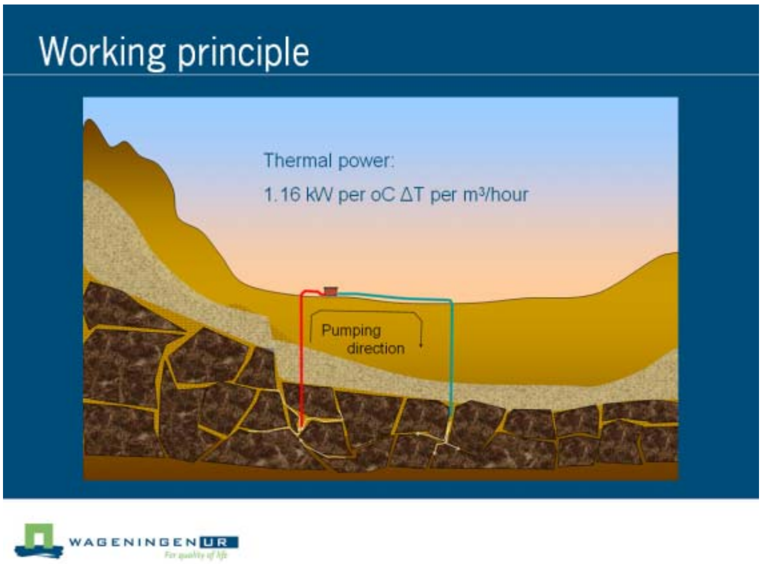
For horticulture, of course the weather conditions are very important. The above slide shows the average climate conditions around Izmir and Antalya, in comparison with Almeria in Spain and the Westland region in the Netherlands. The graph shows the wet bulb temperature (the temperature of the air after adiabatic cooling by adding water) because for horticultural growing conditions the wet bulb is more important than the ambient air temperature.
The graph tells that the Izmir region (Dikily, Aydin) is clearly more favorable than the Antalya region and that, in summer, the conditions near Izmir are also better than the important horticultural area in Spain.



The light conditions in Turkey are better than in Spain and far better than in the Netherlands.



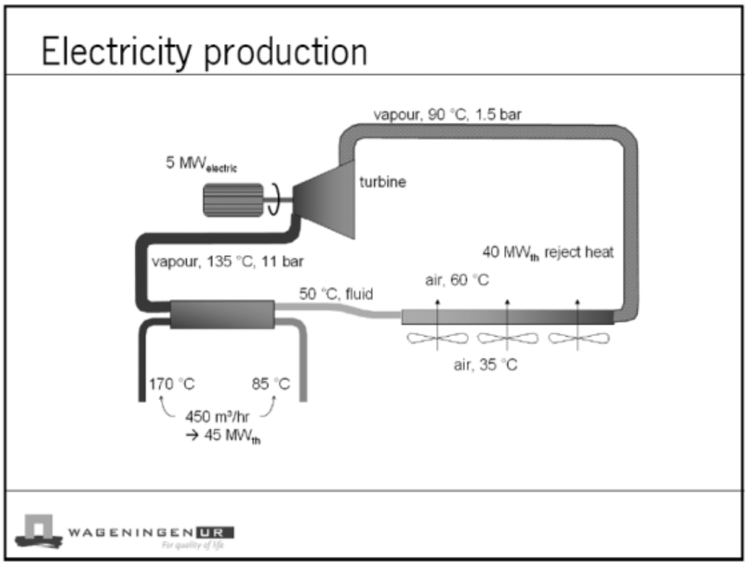
The above slide shows in more detail the major geothermal areas (the map is on the same scale as the previously shown map). In general, geothermal energy for greenhouse heating is more favorable when the of the water brought to the surface is hotter, but even water of 60 °C is suitable. It is this picture that shows the poor perspectives of the Antalya region with respect to this point.



The working principle of geothermal energy is quite simple. In volcanic active areas some parts of the earth crust are slit down along faults. The lower parts are called ‘grabens’. Often the rocky deep soil has a lot of cracks through which water can be transported. When the earth crust is relatively thin the central earth’s heat heats up the rocks and water. When drilling a well into the deep soil water filled cavities the hot water can be pumped up to the surface. Quite often the water pressure is even that high that water flows out spontanuosly.

Due to the recently activated law on geothermal heat, one that pumps up geothermally heated water has to re-inject this water in order not to pollute surface water and not to disturb the deep soil water pressure table. The further the re-injection point is located from the pumping point, the smaller the possibility of mutual influence becomes. In practice a pumping and a re-injection well are separated 1 to 2 km from each other.

The heating power that can be extracted from a geothermal heat source is linearly dependent on the temperature difference between pumped and re-injected water and the flowrate. A rough rule of thumb (resulting in a 16% underestimation) tells that the thermal capacity in kW is equal to the flow rate (in m^3/hr) times the temperature difference (in °C)

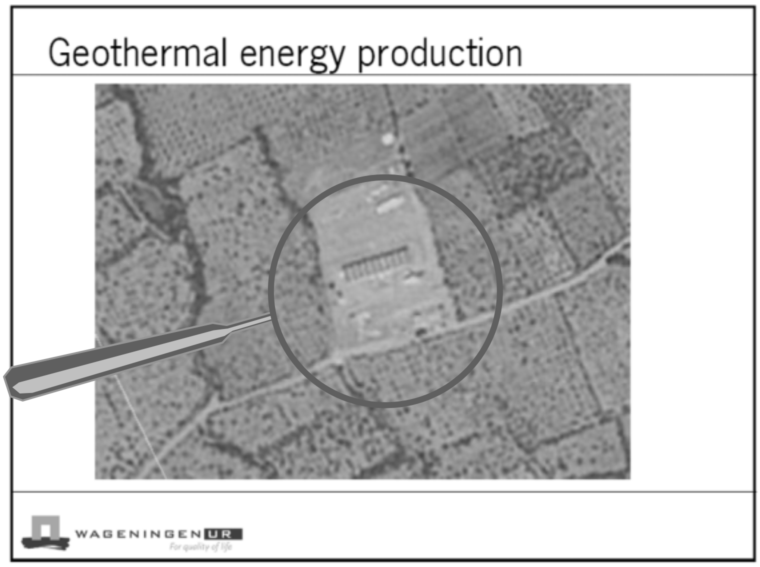


In Turkey, geothermal energy for electricity production draws extra attention. The government is very well aware of the need of non-fossil electricity. A large problem, however, is that the conversion of heat to power is subject to thermodynamics that limit the maximal conversion efficiency. This Carnot-efficiency shows that both the temperature difference between the hottest and coldest point in the thermodynamic cycle and the absolute level of the highest value plays a role.
In the slide, typical temperatures in the Mege Geothermal Elektrik Santrali near Aydin are shown. For the above situation the theoretic maximal conversion efficiency follows from

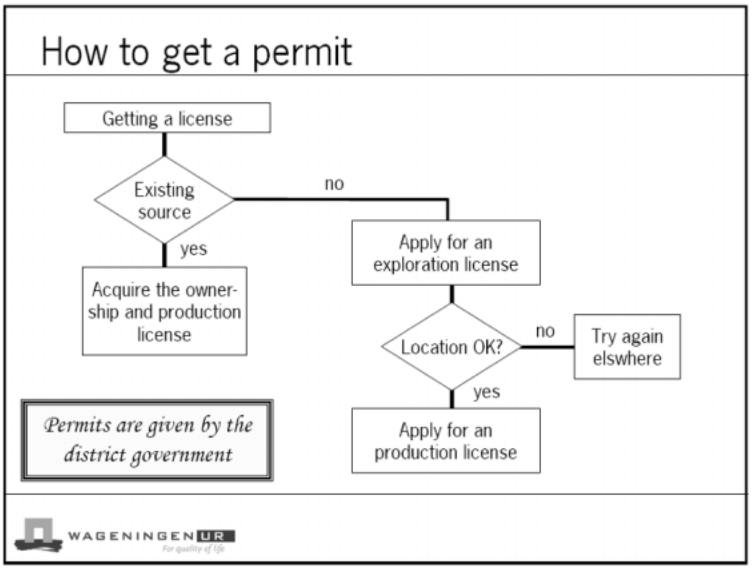
$$\eta_{carnot} = 1 - (135+273)/(50+273) = 0.208$$

in which 273 converts the temperature in °C to K and in which 135 and 50 are the high and low temperatures in the thermodynamic cycle respectively. The comparison between the 5 MW electric power with the 45 MW thermal power results in a working efficiency of 11%. This means that the plant performs with a technical conversion efficiency of 53% of the carnot efficiency. This must be judged as a good practical performance. As an average, power plants perform at 50% of the carnot efficiency.

In the above slide it can be seen that 89% of the geothermal heat is rejected as waste heat into the ambient. This takes place in the condensers of the plant. In these large units the low pressure vapour is condensed (in order to keep the pressure low).
The condensors are very large and can be distinguished as the most significant part of the powerplant looking from space.

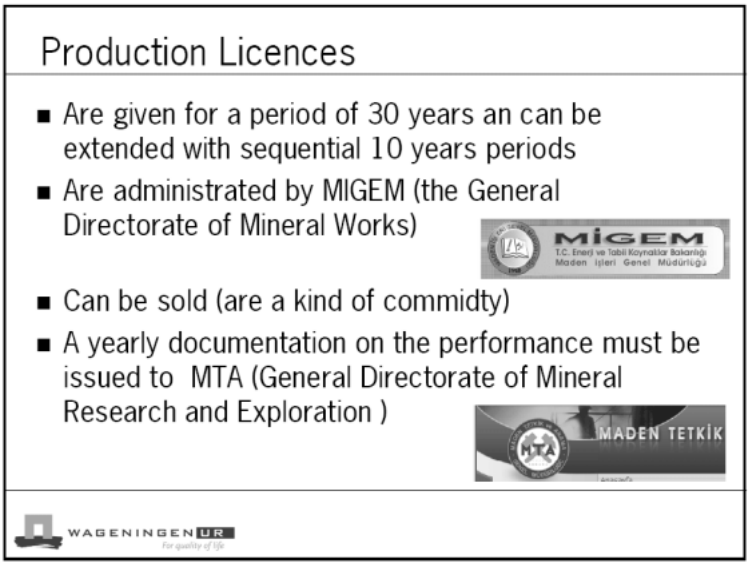


As can be seen in the flow chart of the plant a geothermal power plant has lots of waste heat that could be used for heating greenhouses. The vast majority of the reject heat is dissipated at the condenser. However, since the condenser must work all year round and greenhouses typically have a strong season dependent heat demand, greenhouses must be judged as unsuitable to extract heat from the condenser of a geothermal power plant. However, the temperature of the re-injected water, being 85 °C, is still very suitable for greenhouse heating and a fluctuating heat extraction from this hot water flow doesn't affect the power generation.
Suppose this re-injection water would be cooled to 50 °C by heat application in greenhouses, the thermal heating capacity is 18 MW, which would be sufficient to heat some 15 hectares of greenhouses.
In case these 15 hectares of greenhouses would be attached to this geothermal heat source, the yearly amount of heat extraction from the well would increase from 1.4 PJ to 1.54 PJ, which means an increment of 10%.

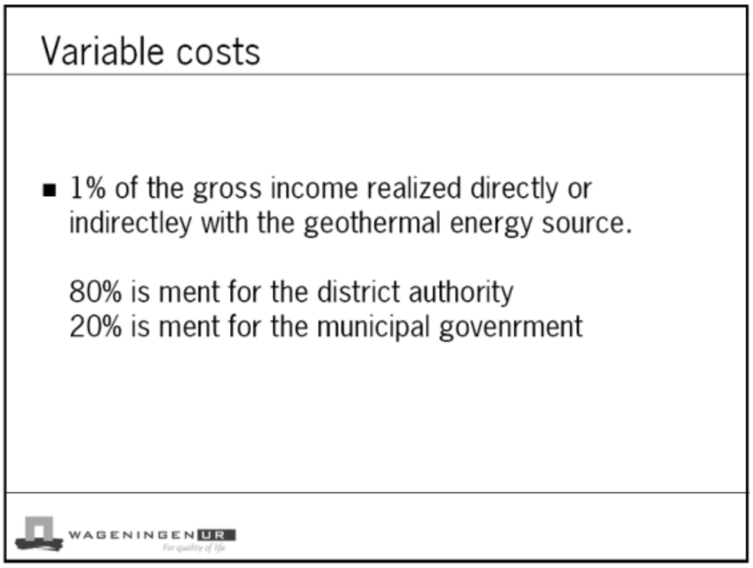


Besides the technical aspects, there are juridical aspects around using geotermal heat. The above sheet shows the ways of getting a permit. This flow chart was deduced from the 'Law on geothermal resources and natural mineral water' (see the Appendix 3).

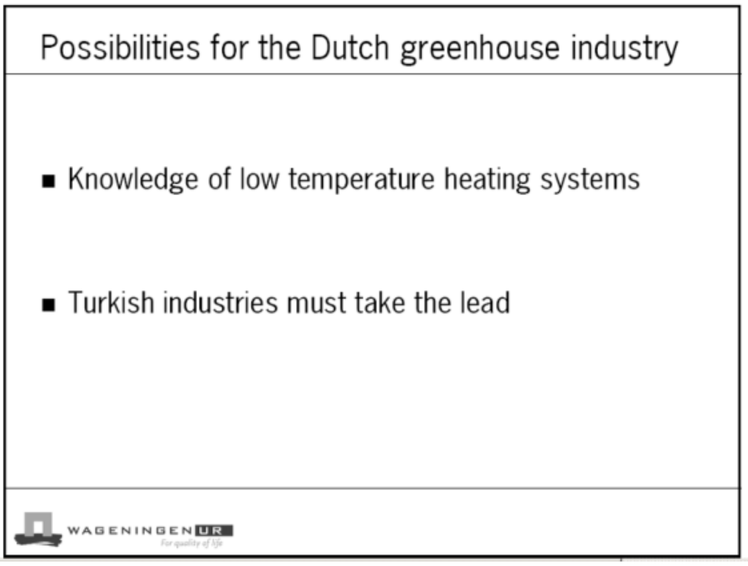
Currently, a lot of exploration is carried out by the MTA (the General Directorate of Mineral Research and Exploration) so there are licenses to be acquired. These are sold by a tendering system by which the highest bidder will get the permit.



Using a geothermal heat source is not free of charge. According to the law presented in Appendix 3 ‘An administration contribution of 1% of gross income of the facilities that use the fluid directly or indirectly shall be paid to the administration’.



When looking at the possibilities for the Dutch Greenhouse industry with respect to the development of geothermal heat for greenhouses there appears to be hardly any special knowledge necessary to apply geothermal heat.



From the perspective of using geothermal heat, only the experience and development of low temperature heating systems can give specific added value. These low temperature heating systems are currently emerging in new Dutch greenhouses because of the development of geothermal heat in the Netherlands as well. Also in combination with heat pumps, low temperature heating systems are getting attention.
Apart from this specific point, of course the Dutch greenhouse industry can provide added value in Turkey with sophisticated greenhouses and horticultural experience. However, this added value is not coupled to geothermal heat and therefore hasn't get attention in this presentation.