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Macedonia – Country Update 2015

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ABSTRACT

Macedonia is characterized with low-temperature geothermal energy utilization, while the medium and high-temperature potentials are still not explored. Nevertheless, even the present available resources are by far underutilized.

This paper gives a summary of the geothermal status in Macedonia comprising the geological background, known hydro-geothermal resources and their potential, present state of geothermal surveys & utilization and main projects' characteristics, with identification and comments on the negatively influencing factors. At the end, prospects of the expected/possible development are summarized.

1. INTRODUCTION

The overall geothermal status in Macedonia has not changed during the last five years; however, there are indications that some new explorations, drillings and utilization will take place. The former State Geological Institute is closed for more than a decade and nowadays a new one is in the process of being established. In other words, for a long period, in Macedonia there is no formal institution which takes care on geothermal issues, such as the collected data from performed explorations, borehole completion, assessment of geothermal fields, exploitation data, sustainable exploitation, geo-heat pumps, etc. However, even though not formally registered, the interest and interventions in obtaining and using the benefits of geothermal resources are obvious. Power generation from geothermal energy is not yet present, but there are indications of foreign interest to explore and utilize such potential. Concerning legislation and regulative on promotion, exploration, development and protection of geothermal resources, no any progress can be observed.

2. GEOLOGY BACKGROUND

2.1 Geological Framework and Tectonic Settings of Macedonia (Micevski, 2003)

In the territory of Macedonia rocks of different age occur, beginning with Precambrian to Quaternary ones. Almost all lithological types are represented. The oldest, Precambrian rocks consist of gneiss, micaschists, marble and orthometamorphites. The rocks of Paleozoic age mostly belong to the type of green schists, and the Mesozoic ones are represented by marble limestones, acid, basic and ultrabasic magmatic rocks. The Tertiary sediments consist of flysch and lacustrine sediments, sandstones, limestones, clays and sands.

With respect to the structural relations the territory can be divided into six geotectonic units (Fig.1): The Cukali-Krasta zone, Western-Macedonian zone, Pelagonian horst-anticlinorium, Vardar zone, Serbo-Macedonian massif and the Kraisthide zone. This tectonic setting is based on actual terrain and geological data without using the geotectonic hypothesis (Arsovski, 1997). First four tectonic units are parts of Dinarides, Serbo-Macedonian mass is part of Rodopes and the Kraisthide zone is part of Karpato-Balkanides distinguished on the Balkan peninsula as geotectonic units of the first stage.

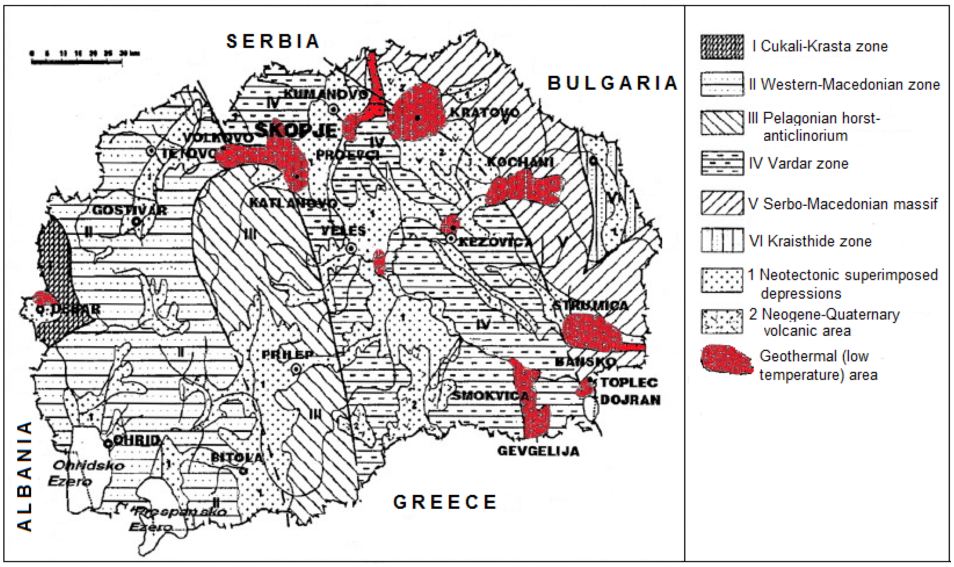

Figure 1: Geological settings and geothermal regions in Macedonia (Arsovski, 1997).

2.2. Geothermal Background (Georgieva, 2002)

The territory of the Republic of Macedonia belongs to the Alpine-Himalayan zone, with the Alpine sub-zone having no contemporary volcanic activity. This part starts from Hungary, across Serbia, Macedonia and North Greece and stretches to Turkey. Several geothermal regions have been distinguished including the Macedonian region, which is connected to the Vardar tectonic unit. This region shows positive geothermal anomalies and is hosting different geothermal systems. The hydro-geothermal systems, at the moment, are the only ones worth exploration and exploitation.

There are 18 known geothermal fields in the country (Fig.2) represented by more than 50 thermal springs, boreholes and wells with hot water, having discharge of about 1,000 l/s with temperatures between 20-79^{o}C. Hot waters are mostly of hydrocarbonate nature, according to their dominant anion, and mixed with equal presence of Na, Ca and Mg. The dissolved minerals range from 0.5 to 3.7 g/l.

All thermal waters in Macedonia are of meteoric origin. Heat source is the regional heat flow, whose value in the Vardar zone is approximately 100 mW/m^2 and crust thickness is 32 km.

3. GEOTHERMAL RESOURCES AND POTENTIAL

Out of the seven geothermal fields identified in the east and northeast part of the country, four have been found to be very promising and three have been explored to the stage of possible practical use. Except the springs in Debarska banja and Kosovrasti, positioned in the West Bosnian-Serbian-Macedonian geothermal zone, all the others are located in the Central Serbian-Macedonian Geothermal Massif, Central and Eastern Macedonia (Fig.2).

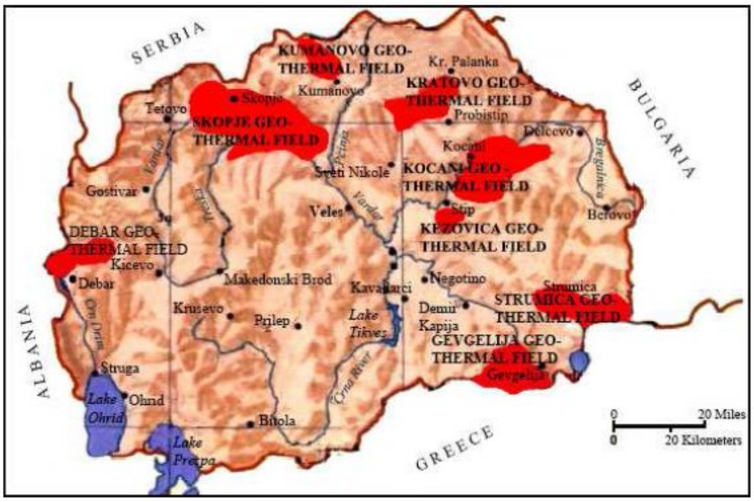

Figure 2: Main geothermal fields in Macedonia (Popovski et al., 2005).

The total available flow of the exploitable sources is 922.74 l/s, which is less than the estimated 1,000 l/s, and differs from the previous values (1,397 l/s) that are the maximum measured short lasting flows. The difference is due to the more precise data concerning permanent capacities of all the flows, after many years of exploitation and measurements.

Temperatures of the flows vary in the range of 24-27°C (Gornicet, Volkovo and Rzanovo) up to 70-78°C (Bansko and Dolni Podlog). Total average temperature is 59.77°C. The biggest potential is in the Kocani geothermal field, with a total maximal flow of up to 350 l/s and temperatures of 65°C (Istibanja) and 75-78°C (Dolni Podlog). Next is the Gevgelija geothermal field, with about 200 l/s and temperatures of 50°C (Negorci) and 65°C (Smokvica). The list of the others is: Debar geothermal field with 160 l/s and temperatures of 40°C (Debarska banja) and 48°C (Kosovrasti), Strumica geothermal field with 50 l/s and 70°C and Kratovo/Kumanovo geothermal field with 71 l/s and temperatures of 31°C (Kumanovska banja) and 48°C (Kratovo).

The real energy potential of the geothermal resource in Macedonia is in direct correlation with the technical/technological feasibility of its application, in accordance to the newest know-how in the country and in the world. A simulation, according to different outlet temperature, is made for all the exploitable geothermal resources in Macedonia. A total available maximum heat power of 173 MW is obtained, which suggests the possibility of annual maximum production of 1.52 TWh/year. This is only a theoretical indication considering that each project has a different range of exploited temperature. In any case this maximum potential cannot be fully exploited, since it is strongly dependent on the utilization factor and the type of application. For instance, the geothermal system in Dolni Podlog (Kocani) has a maximum flow of about 300-350 l/s with temperature of 75°C. If a maximal use of the source could be reached (i.e. effluent water of 15°C), its heat power could increase up to 75-85 MW. However, the applied technical solutions by the users result with temperatures of the effluent water of 40-45°C during the (winter) heating season. These in turn decreases the heat power of the source to 37.7-44.0 MW, i.e. 40-50% of the maximally possible one. For the same geothermal system and composition of users, it is technically and economically feasible to obtain lower temperature of the effluent water of 30°C during the first phase of development (Popovski, 1991), and 25°C during the second phase of development. Such optimization would enable reduction of the losses for 25% and 17% respectively, which is in the acceptable limits even for the countries with longer experience in geothermal energy application. Therefore, depending on the achieved average outlet temperature of projects using available geothermal resources, the following orientation figures for total heat power could be taken: 172.9 MW for 15ºC, 153.7 MW for 20ºC, 134.3 MW for 25ºC, 115.6 MW for 30ºC, 97.2 MW for 35ºC, 78.9 MW for 40ºC and

68.2 MW for 45ºC. According to the presently applied solutions, average outlet temperatures between 30 and 40ºC are taken as representative.

3.1. Geothermal fields in Macedonia

There are 18 localities where geothermal fields occur and geothermal energy is in use for different purposes. The most known areas are listed below.

3.1.1 Kocani valley (Popovski, 2002)

The main characteristics of the Kocani valley geothermal system are: presence of two geo-thermal fields, Podlog and Istibanja, without hydraulic connection between them. The primary reservoir is built by Precambrian gneiss and Paleozoic carbonated schists, where by drilling the highest measured temperature in Macedonia of 79ºC had been obtained. Predicted maximum reservoir temperature is about 100ºC (Gorgieva, 1989). Kocani geothermal system is the best explored system in Macedonia. There are more than 25 boreholes and wells with depths of 100-1,170 m. (Popovski, 2009)

3.1.2 Strumica valley (Popovski, 2002)

The main characteristics of this field are: the recharge and discharge zone occur in the same lithological formation - granites; there are springs and boreholes with different temperatures at small distances; maximum measured temperature is 73^{o}C; the predicted maximum temperature is 120^{o}C (Gorgieva, 1989); the reservoir in the granites lies under thick Tertiary sediments. Bansko geothermal system has not been examined in detail apart from the drilling of several boreholes with depths of 100-600 m. (Gorgieva, 2002)

3.1.3 Gevgelija valley (Popovski, 2002)

There are two geothermal fields in the Gevgelija valley: Negorci spa and Smokvica. The discharge zones in both geothermal fields are fault zones in Jurassic diabases and spilites. These two fields are separated by several km and there is no hydraulic connection between them, despite intensive pumping of thermal waters. The maximum temperature is 54ºC, and the predicted reservoir temperature is 75-100ºC (Gorgieva, 1989). Geothermal system in the Gevgelija valley has been well studied by 15 boreholes with depths between 100-800 m. (Gorgieva, 2002).

3.1.4 Skopje valley (Popovski, 2002)

There are two geothermal fields in the Skopje valley: Volkovo and Katlanovo spa. There is no hydraulic connection between them. The main characteristics of the Skopje hydro-geothermal system are: maximum measured temperature of 54.4^{o}C and predicted reservoir temperature (by chemical geothermometers) of 80-115^{o}C (Gorgieva, 1989); the primary reservoir is composed of Precambrian and Paleozoic marbles; large masses of travertine deposited during the Pliocene and Quaternary period along the valley margins. There are only five boreholes with depths of 86 m in Katlanovo spa, 186 and 350 m in Volkovo and 1,654 and 2,000 m in the middle part of the valley. The last two boreholes are without geothermal anomaly and thermal waters because of their locations in Tertiary sediments with thickness up to 3,800 m. (Gorgieva, 2002)

Figure 3: Location of geothermal projects in Macedonia

4. GEOTHERMAL UTILIZATION

The utilization of thermal waters consists of 7 geothermal projects and 6 spas (Fig.3). All of them had been completed before and during the 1980s. The present state of the projects is as follows.

4.1 Istibanja (Vinica) Geothermal Project

Heating of 6 ha greenhouse complex in combination with a heavy oil boiler for peak loadings. It has been one of the worst completed projects before the crisis, however after the privatization in 2000 it has been reconstructed and optimized with Austrian and Dutch grants and now properly covers the heat requirements of the roses' production for export. The owners are interested to continue with explorations in order to enable geothermal heating of additional 6 ha of greenhouses, but so far cannot achieve a common interest with the municipality as owner of the concession rights.

4.2 Kocani (Podlog) Geothermal Project ("Geoterma")

At present the largest geothermal project in Macedonia, composed of 18 ha greenhouse complex heating, and space heating of public buildings in the center of the town. Due to the economic circumstances, paper industry, vehicle parts industry and rice drying unit have been lost as heat consumers during the last 12 years. Nevertheless, by two Austrian grants, three additional boreholes have been drilled, partial injection of effluent water has been completed and a monitoring system has been introduced in the system. Nowadays, there are activities in the direction to finalize the completion of the reinjection and connection of public buildings in the center of the town. The project operates as a public one and its organizational structure is well covered by the existing team. The only problem in operation is the price of supplied heat, which is kept very low by the State Energy Regulatory Commission, not including the costs of the necessary maintenance, service and development of the system.

4.3 Bansko Geothermal Project

The bankruptcy of ZIK "Strumica" and the slow process of its privatization resulted in the collapse of the organizational structure and proper use of the system. Due to increased number of consumers and failure in covering the peak loadings, in order to enable proper operation, it is necessary to introduce centralized managing system and new exploitation boreholes, as well as considerable technical reconstructions and optimizations. Currently the exploitation concession is owned by one company to heat their greenhouses, but due to unsolved energy managing rules there are other consumers, too. Those are the hotel Car Samuil, Spiro Zakov (rest house, rehabilitation facilities for children), other plastic-houses, rest house Jugotutun, rest house ZIK Strumica, experimental and private plastic-houses.

4.4 Smokvica (Gevgelia) Geothermal System:

Once the largest geothermal system in Macedonia, covering the heating requirements of 22.5 ha glasshouses and of about 10 ha plastic-houses, nowadays is out of operation. At present, only 3 wells out of 7 are exploited with total flow of 90 l/s and temperatures between 63.9-68.5^{o}C, to heat 10 ha greenhouses of which 6 ha glasshouses and 4 ha plastic-houses. When the outside temperatures are very low back-up heavy oil boiler is used.

4.5 Negorci (Gevgelija) Spa

Reconstruction of the heating installations has been finalized and now all the hotel and therapeutic facilities are heated with geothermal energy. Project is in a process of continual step by step modernization.

4.6 Other Spas in Macedonia

Even planned, reconstruction of heating systems and their orientation towards geothermal energy use in Macedonian spas has not been realized due to their undefined property and the absence of funds. Now, when the process is finalized, activities to find possible investors are in progress in Katlanovo Spa, Kezovica Spa and Bansko Spa. However, it is not possible to expect quick results, due to the absence of capital in the country and lack of interest of foreign investors.

The ground source heat pump (GSHP) systems have gone through the inexperienced period and nowadays are becoming more and more popular, although there are no regulative or control mechanisms. The data concerning GSHP are by no means collected and registered. However, according the information gathered, GSHP are usually utilized in the residential sector, mostly for individual houses, therefore it could be estimated that the installed capacity so far is approximately 2.5 MW in approximately 200 units with nearly 15 TJ annually used thermal energy.

In Macedonia there are no geothermal power generation plants. Informally, there are interests to explore the potential and if appropriate, to be exploited for power generation, but so far there are no any formal steps undertaken, neither claimed possible capacity. Several approximate feasibility studies have been made on the potential to use the existing low-temperature geothermal resources via binary plants, but the first figures shows that such an investment is either too high or the available capacity is doubtful.

Table 1: Geothermal energy share in the final and primary energy and energy from RES (2010-2014) (Energy Balance, 2012)

Quantity / year	2010	2011	2012	2013	2014
*Final geothermal energy consumption [TJ]	424	255	438	468	499
Total final energy consumption [TJ]	76,631	78,127	77,775	81,890	86,424
Share of geothermal energy in total final energy consumption [%]	0.55	0.33	0.56	0.57	0.58
Total primary energy [TJ]	114,194	119,219	118,692	124,551	131,964
Share of geothermal energy in primary energy provision [%]	0.37	0.21	0.37	0.37	0.38
Energy from RES [TJ]	16,455	12,745	11,697	12,101	12,997
Share of geothermal energy in the energy produced from RES [%]	2.58	2.00	3.74	3.87	3.84

*Estimated energy content of geothermal water in the country energy balance is 0.18 TJ/10^3 m^3

5. DISCUSSION

"Energy Development Strategy for Republic of Macedonia up to 2030" and "Strategy for Exploitation of Renewable Energy Sources in Republic of Macedonia up to 2020" do not include any foreseen geothermal development as a prospective energy source for Macedonia. Despite the formal attitude, some private initiatives exist, which will probably influence changes in this sector in the near future. Most important among them are: the renewal of the Smokvica geothermal system, reconstruction and expanding of the Bansko geothermal system and foundation of a new one in Dojran. Final completion of the injection system in Kocani is expected to be realized during the next two-three years. It is also expected that a majority of spas would undergo reconstructions with intention to use geothermal energy for heating of the accommodation capacities, but so far there is no such information. Up to now, there is no progress concerning the very prospective geothermal fields Kratovo-Zletovo, Skopje and Kumanovo regions.

Nevertheless, there are many improvements which should be done with the existing legislation in order to facilitate geothermal explorations and application, to enable sustainable exploitation and consider the environmental issues. Those are: definition of sustainable outflows, rights over single geothermal field, obligation to inject the used geothermal water, treatment of the geothermal water as mineral resource instead as energy resource too, calculation methodology for feasible and motivating price for geothermal heat, creation of subsurface register, incentives etc. (Panov, 2011)

There is not any progress in geothermal development in Macedonia for already 20 years; hopefully the situation will change along with the contemporary energy trends and initiatives in the country.

REFERENCES

Arsovski M.: Tektonika na Makedonija, Stip, 1997

Dimitrov K., Gorgieva M. and Popovski K.: Geothermal Energy Resources and their Use in the Republic of Macedonia, Proceedings of the World Geothermal Congress 2000 Kyushu – Tohoku, Japan, May 28 –June 10, 2000

Energy Balance of Republic of Macedonia for the Period 2013-2017, Official Gazette of Republic of Macedonia, no.170, 28.12.2012

Georgieva M.: Summary of Fundamentals for Evaluation of the Geothermal Potential of the Vardarian Zone and Serbian-Macedonian Massif at the Teritorry of the Republic of Macedonia, Annual Workshop of MAGA, Ohrid 2003

GeorgievaM., Gorgiev D., Popovski K., Dimitrov K., Manasov S.: Inferred Section of the Main (Low-temperature) Geothermal Systems in the Republic of Macedonia, Proceedings World Geothermal Congress 2000 Kyushu - Tohoku, Japan, May 28 – June 10, 2000

Gorgieva M., Popovski K., Gorgiev D.: Geothermal Energy in Macedonia, State-of-the-Art and Perspectives, International Geothermal Days of ISS “Greece 2002”, Proceedings, Skopje 2002

Macedonian Academy of Science and Arts, Energy Development Strategy for Republic of Macedonia for the period 2008-2020 with vision up to 2030, Skopje, 2009

Macedonian Academy of Science and Arts, Strategy for Exploitation of Renewable Energy Sources in Republic of Macedonia up to 2020, Skopje, 2010

Micevski E.: Geotermalen potencijal na jugo-zapadniot del na Makedonija, Annual Workshop of MAGA, Ohrid 2003

Popovski K.: Feasibility Study on Possible Investments in Geothermal Projects in Macedonia, WB Study, Skopje 2002

Popovski K.: Geothermal Energy Use in Macedonia, International Conference GEAIA, Athens 2004.

Popovski K., Micevski E., Popovska-Vasilevska S.: Macedonia – Country Update 2004, Proceedings World Geothermal Congress, Antalya, Turkey, 24-27 April 2005

Panov Z., Gulev G., Ilievski A.: Analysis of the Regulation for Exploration, Exploitation and Utilization of the Geothermal Water in the Republic of Macedonia, Kocani, 2011

STANDARD TABLES

Table 1: Present and planned production of electricity

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2014			1010	5324	581	1089			5.2	17	1591	6430
Under construction in December 2014					200	370			150	100	350	470
Funds committed, but not yet under construction in December 2014												
Estimated total projected use by 2020			1310	7000	1350	2800			440	330	3100	10130

Table 3: Utilization of geothermal energy for direct heat as of 31 december 2014 (other than heat pumps)

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Bansko*	D	53	69	30			8.65	35	180.05	0.66
Istibanja	G	21.5	61	30			2.79	15	61.14	0.69
Kocani**	D	180	75	30			33.9	57	338.32	0.31
Negorci	H	80	50	40			0.84	5	6.6	0.25
TOTAL							**46.18**		**586.11**	**0.4**

D = District heating, G = Greenhouse, H = Individual space heating (other than heat pumps)

Table 4: Geothermal (ground-source) heat pumps as of 31 December 2014

Locality	Ground or Water Temp. (°C)[1)]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2)]	COP[3)]	Heating Equivalent Full Load Hr/Year[4)]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Approximation - no data available	10	2,500	200	V	4		15	
TOTAL	10	2,500	200	V	4		15	

V = vertical ground coupled

Table 5: Summary table of geothermal direct heat uses as of 31st December 2014

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating	0.84	6.6	0.25
District Heating*	42.55	518.37	0.39
Air Conditioning (Cooling)			
Greenhouse Heating	2.79	61.14	0.69
Fish Farming			
Animal Farming			
Agricultural Drying			
Industrial Process Heat			
Snow Melting			
Bathing and Swimming			
Other Uses (specify)			
Subtotal	46.18	586.11	0.4
Geothermal Heat Pumps	2.5	15	0.39
TOTAL	48.68	601.11	0.4

*On average 85% used for greenhouse heating

Table 7: Allocation of professional personnel to geothermal activities (Restricted to personnel with University degrees)

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010			1		1	
2011			1		1	1
2012			1		1	1
2013			1		1.5	1
2014			1		1.5	1
Total			5		6	4

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Table 8: Total investments in Geothermal in (2014) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	x	x	x	x		
2000-2004	x	x	x	x		
2005-2009	0.5	1.5	1	x	10	90
2010-2014	0.5	x	x	x		100