

General Evaluation of the Geothermal Potential in Vietnam and the Prospect of Development in the Near Future

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ABSTRACT

The geothermal resources have been studied as a new energy sources in Vietnam ten years ago. Up to now, there are 3 projects funded by Vietnamese government for the energy purpose aimed to investigate and evaluate the geothermal potential in the South - Central, North Central and West - Northern parts where are the most geothermal potential energy in Vietnam territory and 1 project of research and evaluation of the feasibility of geothermal utilization in some certain geothermal sources contributing to the energy balance in Vietnam.

The study results indicate that there are 269 geothermal sources in Vietnam territory with the surface temperatures above 30°C. The total energy capacity is estimated up to 648.9Mwt. But the capacity of geothermal utilization for energy is just 1-2Mwt for heating iodide-salt production. The rest of utilization is for spar, swimming pool, tourism etc.

1. INTRODUCTION

The investigation and research of geothermal resources as a new energy have been carried out formally in the recent decades. Vietnamese government has supported the investigation and evaluation of geothermal potential.

The General Survey of Geology had designed the project: "Evaluation of geothermal resources as the base to design, exploit and utilize for the energy purposes in some prospective areas". Based on the combination of hot spring resources nation-wide with some investigating itinerary, the project of geothermal potential evaluation has been carried out. The prospective zonalization together with the study of use of the energy to dry some of the agriculture products (tea leaves, coconut, cassava...) in My lam (Tuyen Quang province) and Hoi Van (Binh Dinh province).

Since 1993 to 1998, there were two projects of research and evaluation of geothermal potential in two areas named: "Study and evaluation of geothermal potential in the territory form Quang Nam - Da Nang to Ba Ria - Vung Tau" and "Study and evaluation of geothermal potential in the North of Central Vietnam"

Until now, there are not any geothermal resources that are used for electric generation in Vietnam. In the past few years, the Ormat Inc. had got the permission from Vietnamese government to establish the feasibility to construct the geothermal power plants in south central Vietnam.

2. DISTRIBUTION OF GEOTHERMAL RESOURCES IN VIETNAM

According to the statistic data of the year 2000, there are 269 geothermal resources have discovered in Vietnam in which there are 140 warm spring and 80 hot spring. Of them there are 41 very hot in which 4 are extremely hot. The geothermal resources have been distributed following the geographic areas in Vietnam territory.

Table 1: Hot springs classification according to the temperatures and potential areas.

Temperature grades	Areas						Summated by temp. grades	%
	North-west	North-east	North-plain	North-central	South-central	South		
Warm (30-40°C)	35	6	9	11	27	52	140	52,0
Moderate (41-60°C)	38	3	3	19	20	1	84	31,2
Very hot (61-100°C)	6	2	2	11	20	0	41	15,2
So hot (>100°C)	0	0	3	1	0	0	4	1,5
Summated by area	79	11	17	42	67	53	269	
%	29,4	4,1	6,3	15,6	24,9	19,7		100%

Considering the entire Vietnam territory (Table 1) we found that:

2.1. North-western Vietnam

This area has the biggest number of geothermal hot springs (79) making up 29.4% of the numbers of geothermal resources in the country. The second largest number is 67 making up 24.9%. Based on the temperature, almost of the hot water springs are located in South Central area. There are 20 geothermal resources making up 48.8% of the total number of 41 very hot water sources. The geothermal resources in the Northwestern area distribute in the North-west of Northern plain of Vietnam in the provinces of Lai Chau, Son La, Hoa Binh, Yen Bai, Lao Cai and Phu Tho. They appear along the fault systems in NW-SE direction.

2.2. The Northern Plain and Southern Plain

They are the actezi reservoirs those were covered by very thick Quarternary sediment layers. So, the hot water cannot be exposed on the ground surface. They were only discovered in the boreholes, especially, the deep bore holes for oil exploration in Thai Binh and Nam Dinh provinces. These hot water resources are so hot waters (100°C-150°C) at the depth of 1000-3000m. According to the geological investigation and exploration of oil, it is surely that the numbers this kind of drilling holes are increased day by day. In the continental shelf, there are 57 wells of oil drilling of the depth from 300 to 4300m in the Red River

basin. The highest temperature measured at the depth of the well is 179.8°C. In Cuu Long basin, there are 40 deep wells from 400-4500m, the highest temperature is 145°C.

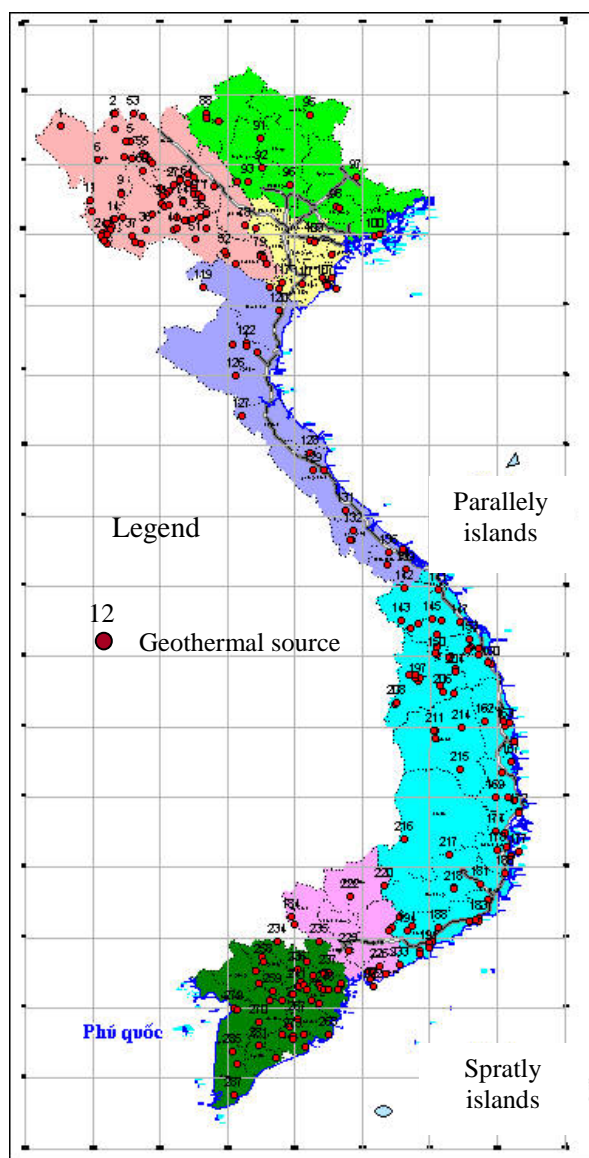


Fig. 1: Distribution of geothermal sources

2.3. NE Vietnam

There are 11 geothermal resources of which there are 5 hot springs and 6 bore holes. The Bo Duot geothermal resource in Thuong Son commune, Bac Quang district, Ha Giang province has the temperature of 71.5°C and the water consists of HCO₃-SO₄ - Na, M=0.18g/l. My Lam geothermal resource in Tuyen Quang province with temperature of 64°C and the water consists of HOC₃-Na, M=0.28g/l. Along the coastal line of Quang Ninh, through the investigation and exploration for ground water, we discovered the Quang Hanh and Tam Hop hot springs. Besides, we meet with some individual wells in Na Rua of Cao Bang province and La Hien of Thai Nguyen province.

2.4. North Central Vietnam.

The distribution of geothermal sources is concentrated in Quang Binh, Quang Tri, Thua Thien – Hue and Quang Nam provinces. In which there are 11 of 42 resources with very high temperature, especially the Lo Voi geothermal resources. This type of exposure consists of many springs

with very high temperature ranged from 95 to 100°C with the total flow rate of about 20l/s. Some other sources also has high temperature such as Son Kim of Ha Tinh province with the temperature of 78°C, Thanh Tan of Thua Thien Hue province with the temperature of 68°C and Huyen Co of Quang Tri province with the temperature of 70°C.

2.5. South central Vietnam

The geothermal with high temperature those are exposed in the south central are distributed mainly in the transitional area between the hill and mountain areas and coastal plain of Quang Ngai, Khanh Hoa and Phu Yen provinces etc. There are 8 geothermal resources with the surface temperature is higher than 70°C such as the Binh Chau – 83°C, Hoi Van – 83°C in Vung Tau and Binh Dinh provinces.

The result of geothermal potential evaluation by the method of surface temperature is as in Table 2:

Table 2: The geothermal potential in the different areas.

Geothermal area	Number of sources	Total energy (MW)		The geothermal resources with prospective potential for exploration		
		Natural	Prediction	> 3MW	1-3MW	<1MW
North west	79	13,5	107	10	25	44
North east	11	6,5	42,3	5	3	3
North plain	17	10	35,6	5	3	9
North central	42	20	59	4	10	28
South central	67	31	127	14	18	35
South	53	22	278	33	11	9
Total	269	103	648,9	71	70	128

Resulting from Table 2, we realized that:

The geothermal area in south central Vietnam has many geothermal resources with expected energy of more than 3MW. But the thermal gradient in the south is very small (2-2.5°C/100m). If we want to exploit for the energy the calculated temperature of 150°C in this area, the depth of the borehole need to be drilled is more than 4000m. So, the expense will be very high. The above result is only used for reference but not significant for the use of geothermal energy in Vietnam.

3. POTENTIAL OF GEOTHERMAL AREAS IN VIETNAM

3.1 The south central Vietnam

This is the most potential area with the expected total energy is 127MW can be exploited for multi-utilization. There are 14 of 72 resources with predicted energy of more than 3MW. The geothermal resources with high potential are Mo Duc: 3.9MW, Thach Bich: 2.9MW, Phu Sen: 4.2MW, Tu Bong: 3.8MW, Hoc Chim 4.2MW, Danh Thanh 3.5MW and Binh Chau: 8.4MW. The deep temperatures of the resources are changed between from 110°C to 200°C. The geothermal resources with high energy in south central are usually exposed in the coastal plain in the direction of North to South from Quangnam - Danang to Baria - Vungtau. They distributed at the conjunction between the deep faults of structural zonalization that is the sub-parallel faults and the young faults of Vungtau – Phan Rang oriented at East – North and Sub-parallel.

3.2 The North west geothermal area

This is the area of second largest potential with the capacity of 107MW and total natural energy of geothermal resources are: 13.5KW. This area comprises 79 geothermal resources with the surface temperature from 30 to 78°C. The geothermal sources exposed mainly along the fault systems oriented NW-SE (Song Da fault, Thuan Chau fault, Song Hong and Song Chay faults). The geothermal sources relate with the volcanic activities bazan of Quarternary. Nearly a half of the number of Northwest part belongs to SO₄-Ca-Mg, some of them belong to Cl-SO₄-Na and other is HCO₃-Na water type. The deep temperature of geothermal resources is in between 103°C and 232°C. In which there are 35 sources with the predicted potential is more than 1MW. The big potential sources are: Na Un 6.2MW, Na Hai: 4.3MW and Pom Lot: 3MW.

3.3 North central Vietnam

This is the third biggest geothermal potential area in Vietnam with predicted energy is 59MW. Especially, the Bang geothermal source with the predicted geothermal potential may reach to 59MW. Especially, the energy of Bang geothermal resource is estimated at 28MW that is equivalent to 50% the energy capacity in the area and it is the most potential resource in Vietnam. Especially, the relation between the deep faults and the geothermal sources is very clear in some areas. Especially the deep faults and the geothermal resources are represented in some areas. The Kim Da and Cua Dat geothermal resources spread out along the fault of Tuong Duong – Thuong Xuan. The Son Kim and Ngu Hoa geothermal sources located on the Rao Nay fault. The Bang geothermal source with the highest temperature in the North central Vietnam (100°C) located in the north of Dong Hoi – Phu Vang fault, there are two geothermal sources in the south part of this fault named My An and HU7. At the south west of study area, there are geothermal sources of Huyen Co and Duong Hoa that located along Dak Rong – A Luoi. In general, the geothermal resources of north central Vietnam are relating to deep faults. The geothermal fluid has high surface temperature ranged between 60-100°C. The deep temperature, according to the calculation, is ranged between 120-210°C. There are also some other big geothermal potential such as Son Kim: 3.2MW, Huyen Co; 2.4MW and Que Loc; 3.9MW.

3.4 Northeast geothermal area

The study result shows that the boreholes of geothermal have very high flow rate. The manifestation in the area is only seen in Ha Giang and Tuyen Quang provinces. There is almost no manifestation in the other area but they are only seen when drilling for water. So, the exact evaluation of geothermal potential in the area is very difficult. There are only three geothermal sources which have good geothermal potential for energy exploitation, they are: Bo Luoi in Ha Giang province; My Lam in Tuyen Quang Tuyen Quang province and Tam Hop in Quang Ninh province with the predicted energy is 42.3MW. Most of the geothermal resources in the area are bicarbonate sodium (HCO₃-Na) or SO₄-Ca and HCO₃-SO₄-Ca-Mg types of water. Taking in to account the geothermal origin, they relate to the deep zonalization faults and weak convection, there is almost no evidence of expose relating to young basalt eruption.

3.5 North plain geothermal area

In this area, the geothermal sources are only exposed in Ba Vi - Ha Tay province, Nho Quan – Ninh Binh province and

the other sources have been developed during the exploration drilling for oil and ground water. The past data and the result of evaluation of geothermal potential have shown that the deep temperature of the geothermal resources is ranged between 100 and 150°C. They are distributed at the depth of 3000m. Total predicted energy is 35MW; in fact it may be much higher because there are many bore holes with the unclear flow rate in Thai Binh and Nam Dinh provinces.

The result of geothermal potential evaluation shows that, the high potential areas in Vietnam are South Central, North Western and North Central Vietnam. Based on the criteria of origin (geo-tectonics), physics (high temperature) and chemical composition, they are relating to the hydrothermal system of young magma. The result of thermogenetic measurement due to radioaction of the soil and rock that collected from area of hot water manifestation shown that the heat is smaller than the general heat of the earth crust. This heat is not able to boil the water but can compensate for the lost energy of the water. So, the cause that makes the water hot is not the heat of radioreactive of the crust but due to the heat coming from depth of the crust. The heat goes up along the young fault or re-active by the machanism of convective and circular or due to hydrothermal activities of young intrusion. Here is no data of temperature measurement in the drilling holes of exploration and exploitation in the above areas. So, the determination of depth of geothermal resource distribution cannot be realized. According to the scientists of ORMAT company who have investigated the some geothermal resources in South central area for investigation to invest and construct the Geothermal Electric Plants, the geothermal reservoirs distributed in the depth of 1000m.

4. GEOTHERMAL UTILIZATION

The geothermal utilization in Vietnam has been studied and applied in the year of 80's of the end of the last century for agricultural heating (tea, coconut-palm, manioc...) in My Lam (Tuyen Quang province) and Hoi Van (Binh Dinh province) geothermal fields with the satisfactory result. However, they are the first pilots in the geothermal utilization, and are carried out in difficult situation of economy and techniques in Vietnam, so there is still much limitation.

Besides, there are some research and applied projects of geothermal resources in order to maintain the crayfish throughout the winter.

Up to now, the main trend of geothermal utilization is for the spar, treatment, bottling and tourism such as: in My Lam, Quang Hanh, Binh Chau, Hoi Van geothermal resources etc... As about the utilization of energy generation, it was just started in 1997 by Pharmacy Company of Binh Dinh province. The company constructed a base to produce crystal salts mixed with iodine following the method of evaporation of iodine-salty solution by using the heat of geothermal fluids. The production is about 7000 ton/year.

The geothermal exploitation for electric power generation is begun by ORMAT Company in cooperation with Electric Investigation and Design Company No1. They had finish the pre-feasibility report aimed to construct 6 electric geothermal plants in central Vietnam with the total capacity upto 112.7 MW. But due to some obstacles the project has been still postponed.

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY (Installed capacity)

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (Wind and Solar)		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 2004			5642	39540	4119	28865			0.2 0.7	1.4 4.9	9761.9	68411.3
Under construction in December 2004			1200	8409	130	911			N/A		1330	9320
Funds committed, but not yet under construction in December 2004	112.7		N/A		N/A		2000	N/A	N/A			
Total projected use by 2010	N/A		11760	842414	8474	59385	NA		N/A	N/A	20234	901799

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2004

¹⁾ N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

²⁾ 1F = Single Flash B = Binary (Rankine Cycle)
 2F = Double Flash H = Hybrid (explain)
 3F = Triple Flash O = Other (please specify)
 D = Dry Steam

³⁾ Data for 2004 if available, otherwise for 2003. Please specify which.

Locality	Power Plant Name	Year Com-missioned	No. of Units	Status ¹⁾	Type of Unit ²⁾	Total Installed Capacity MWe	Annual Energy Produced 2004 ³⁾ GWh/yr	Total under Constr. or Planned MWe
Quang Binh	Lethuy			N	B	N/A		23,3
Quang Ngai	Moduc			N	B	N/A		21,4
Binh Dinh	Hoivan			N	B	N/A		18
Khanh Hoa	Tubong			N	B	N/A		18
Quang Ngai	Nghiathang			N	B	N/A		18
Khanh Hoa	Danhthanh			N	B	N/A		14
Total								112,7

**TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT
AS OF 31 DECEMBER 2004 (other than heat pumps)**

- ¹⁾ I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
- H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)
- ²⁾ Enthalpy information is given only if there is steam or two-phase flow
- ³⁾ Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (°C) - outlet temp. (°C)] x 0.004184 (MW = 10⁶ W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001
- ⁴⁾ Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10¹² J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154
- ⁵⁾ Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less, since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type ¹⁾	Maximum Utilization					Capacity ³⁾ (MWt)	Annual Utilization		
		Flow Rate (kg/s)	Temperature (°C)		Enthalpy ²⁾ (kJ/kg)			Ave. Flow (kg/s)	Energy ⁴⁾ (TJ/yr)	Capacity Factor ⁵⁾
			Inlet	Outlet	Inlet	Outlet				
Hoivan	I	8,6	83	45			1,37	4,3	21,6	0,50
QuangNgan	B	1	60	35			0,10	0,3	1,1	0,33
Mylam	B	13,2	64	35			1,60	4,4	16,8	0,33
TamHop	B	22,05	55	35			1,84	7,4	19,4	0,33
Tienlang	B	1,4	54	35			0,11	0,5	1,2	0,33
Namhai	B	10	104	35			2,88	3,3	30,3	0,33
Kenhga	B	1,5	55	35			0,13	0,5	1,3	0,33
Sonkim	B	5	78	35			0,90	1,7	9,5	0,33
Bang	B	40	100	35			10,87	13,3	114,3	0,33
Myan	B	1,2	50,9	35			0,08	0,4	0,8	0,33
Thachbich	B	5	68	35			0,69	1,7	7,3	0,33
Moduc	B	6	80	35			1,13	2,0	11,9	0,33
Hoivan	B	8,5	71	35			1,28	2,8	13,5	0,33
Tubong	B	7,3	73	35			1,16	2,4	12,2	0,33
Truongxuan	B	4,5	69	35			0,64	1,5	6,7	0,33
Vinhphuong	B	18	48	35			0,98	6,0	10,3	0,33
Danhthanh	B	7,9	72	35			1,22	2,6	12,9	0,33
Bangoi	B	7	55	35			0,59	2,3	6,2	0,33
Tanmy	B	2,2	50	35			0,14	0,7	1,5	0,33
Binhchau	B	15	82	35			2,95	5,0	31,0	0,33
TOTAL							30,65			

**TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES
AS OF 31 DECEMBER 2004**

¹⁾ Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

²⁾ Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10¹² J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

³⁾ Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10⁶ W)

Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity ¹⁾ (MWt)	Annual Energy Use ²⁾ (TJ/yr = 10 ¹² J/yr)	Capacity Factor ³⁾
Individual Space Heating ⁴⁾			
District Heating ⁴⁾			
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying ⁵⁾			
Industrial Process Heat ⁶⁾	1,37	21,6	0,50
Snow Melting			
Bathing and Swimming ⁷⁾	29,28	58,9	0,06
Other Uses (specify)			
Subtotal			
Geothermal Heat Pumps			
TOTAL			

⁴⁾ Other than heat pumps

⁵⁾ Includes drying or dehydration of grains, fruits and vegetables

⁶⁾ Excludes agricultural drying and dehydration

⁷⁾ Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2000 TO DECEMBER 31, 2004 (excluding heat pump wells)

¹⁾ Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration ¹⁾	(all)					
Production	>150° C					
	150-100° C					
	<100° C		10			1.5
Injection	(all)					
Total			10			1.5

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2000	15					
2001	18					
2002	18					
2003	15					
2004	15					
Total	81					

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2004) US\$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling Million US\$	Field Development Including Production Drilling & Surface Equipment Million US\$	Utilization		Funding Type	
			Direct Million US\$	Electrical Million US\$	Private %	Public %
1990-1994	0.2	N/A				100
1995-1999	0.2	N/A				100
2000-2004	0.2	N/A				100