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Geothermal Power Generation in the World 2010-2014 Update Report

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ABSTRACT

We have analyzed the major activities carried out for geothermal electricity generation since WGC2010.

New data has been taken from WGC2015 Country Update reports, private communications from IGA members and Affiliated Organizations, and we would like to acknowledge all IGA friends for their valuable help. Other updates have been collected from websites of private and public organizations involved in geothermal development. Plants under construction, which are expected to be commissioned in 2015, are included in the installed capacity. An increase of about 1,7 GW in the five year term 2010-2015 has been achieved (about 16%), following the rough standard linear trend of approximately 350 MW/year, with an evident increment of the average value of about 200 MW/year in the precedent 2000-2005 period (Bertani, 2005a, 2005b, 2006, 2007, 2010, 2012 and 2013).

1. INTRODUCTION

The total installed capacity from worldwide geothermal power plant is given in tables I and II and in figures 1 and 2.

For reaching the forecasting of 2020, based on an accurate accounting of all the existing projects at an executive stage, a clear change in the present linear growing trend should be necessary.

In table III data from all the countries currently generating geothermal electricity are presented, with the 2010 and the updated at 2015 values of installed capacity and the produced energy per year, the increment since 2010 both in absolute terms and in percentage, and the aforesaid mentioned short term forecasting to year 2020 for the installed capacity. In figure 3 a world map of the year 2015 installed capacity is presented.

Table I: Total worldwide installed capacity from 1950 up to end of 2015 and short term forecasting.

Year	Installed Capacity MWe	Produced Energy GWh
1950	200	
1955	270	
1960	386	
1965	520	
1970	720	
1975	1,180	
1980	2,110	
1985	4,764	
1990	5,834	
1995	6,832	38,035
2000	7,972	49,261
2005	8,933	55,709
2010	10,897	67,246
2015	12,635	73,549
2020	21,443	

Table II: Total worldwide installed capacity from 1995 up to end of 2015 and short term forecasting for continent.

EUROPE	Installed in 1995	Energy in 1995	Installed in 2000	Energy in 2000	Installed in 2005	Energy in 2005	Installed in 2010	Energy in 2010	Installed in 2015	Energy in 2015	Forecasting for 2020
COUNTRY	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW
EUROPE	722	3.881	1.019	5.864	1.124	7.209	1.643	11.371	2.133	14.821	3.385
AFRICA	45	366	52	397	136	1.088	209	1.440	601	2.858	1.601
AMERICA	3.800	21.303	3.390	23.342	3.911	25.717	4.565	26.803	5.089	26.353	8.305
ASIA	1.980	10.129	3.075	17.390	3.290	18.903	3.661	23.127	3.756	22.084	6.712
OCEANIA	286	2.353	437	2.269	441	2.792	818	4.506	1.056	7.433	1.440
TOTAL	6.832	38.032	7.973	49.261	8.903	55.709	10.897	67.246	12.635	73.549	21.443

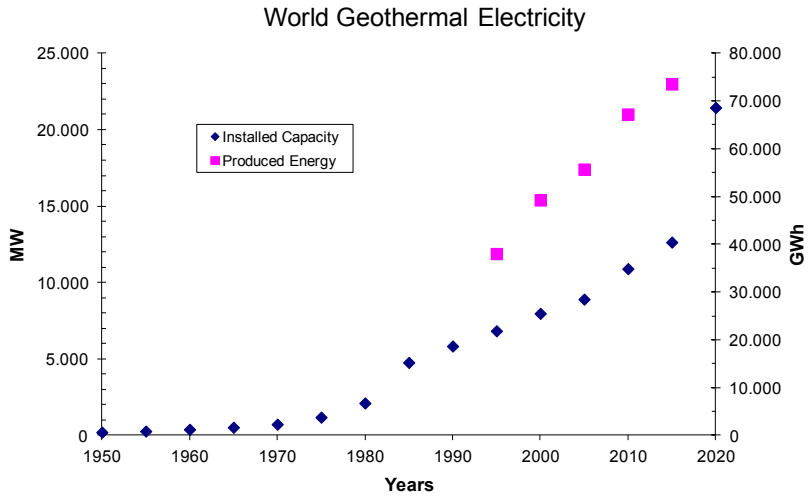

Figure 1: Installed capacity from 1950 up to 2015 (Left, MWe) and produced electricity (Right, GWh).

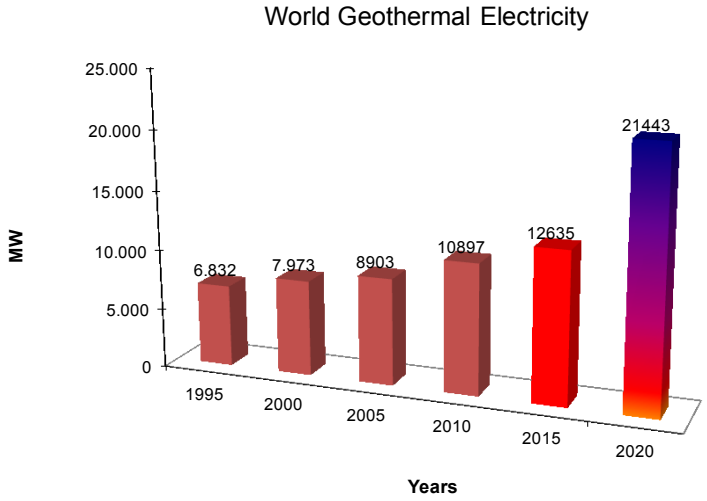

Figure 2: Forecasting of the installed capacity in 2020 [21.4 GWe].

Table III: Installed capacity and produced energy for 2010, 2015, and forecasting for 2020.

COUNTRY	Installed in 2010	Energy in 2010	Installed in 2015	Energy in 2015	Forecast for 2020	Increase since 2010			
	MWe	GWh	MWe	GWh	MWe	MWe	GWh	Capacity %	Energy %
ALGERIA					1				
ARGENTINA					30				
ARMENIA					25				
AUSTRALIA	0.1	0.5	1,1	0,5	20	1			
AUSTRIA	1.4	3.8	1.2	2.2	6				
BOLIVIA					40				
CANADA					20				
CHILE					150				
CHINA	24	150	27	150	100	3		12%	
COSTA RICA	166	1,131	207	1,511	260	42	380	25%	34%

COUNTRY	Installed in 2010	Energy in 2010	Installed in 2015	Energy in 2015	Forecast for 2020	Increase since 2010			
	MWe	GWh	MWe	GWh	MWe	MWe	GWh	Capacity %	Energy %
CZECH REPUBLIC					5				
DJIBUTI					50				
DOMINICA					10				
ECUADOR					40				
El SALVADOR	204	1,422	204	1,442	300		20		
ETHIOPIA	7.3	10	7.3	10	50				
FRANCE	16	95	16	115	40		20		21%
GERMANY	6.6	50	27	35	60	20	-15	280%	-30%
GREECE					40				
GUATEMALA	52	289	52	237	140				
HONDURAS					35				
HUNGARY					5				
ICELAND	575	4,597	665	5,245	1,300	90	648	16%	14%
INDIA					10				
INDONESIA	1,197	9,600	1,340	9,600	3,500	143		12%	
IRAN					5				
ITALY	843	5,520	916	5,660	1,000	74	140	9%	3%
JAPAN	536	3,064	519	2,687	570	-16	-377	-3%	-12%
KENYA	202	1,430	594	2,848	1,500	392	1,418	194%	99%
LATVIA					5				
MEXICO	958	7,047	1,017	6,071	1,400	59	-976	6%	-14%
MONTSERRAT					5				
NETHERLAND					5				
NEVIS					35				
NEW ZEALAND	762	4,055	1,005	7,000	1,350	243	2,945	32%	73%
NICARAGUA	88	310	159	492	200	72	182	82%	59%
PAPUA-NEW GUINEA	56	450	50	432	70	-6	-18	-11%	-4%
PERU					40				
PHILIPPINES	1,904	10,311	1,870	9,646	2,500	-34	-665	-2%	-6%
POLAND					1				
PORTUGAL	29	175	29	196	60		21		12%
ROMANIA			0,1	0,4	5	0,1	0,4		
RUSSIA	82	441	82	441	190				
SLOVAKIA					5				
SPAIN					40				
SWITZERLAND					3				
TAIWAN			0,1		1	0,1			
THAILAND	0.3	2.0	0,3	1,2	1				
TURKEY	91	490	397	3,127	600	306	2,637	336%	539%
UK					15				
USA	3,098	16,603	3,450	16,600	5,600	352		11%	
TOTAL	**10,897**	**67,246**	**12,635**	**73,549**	**21,443**				

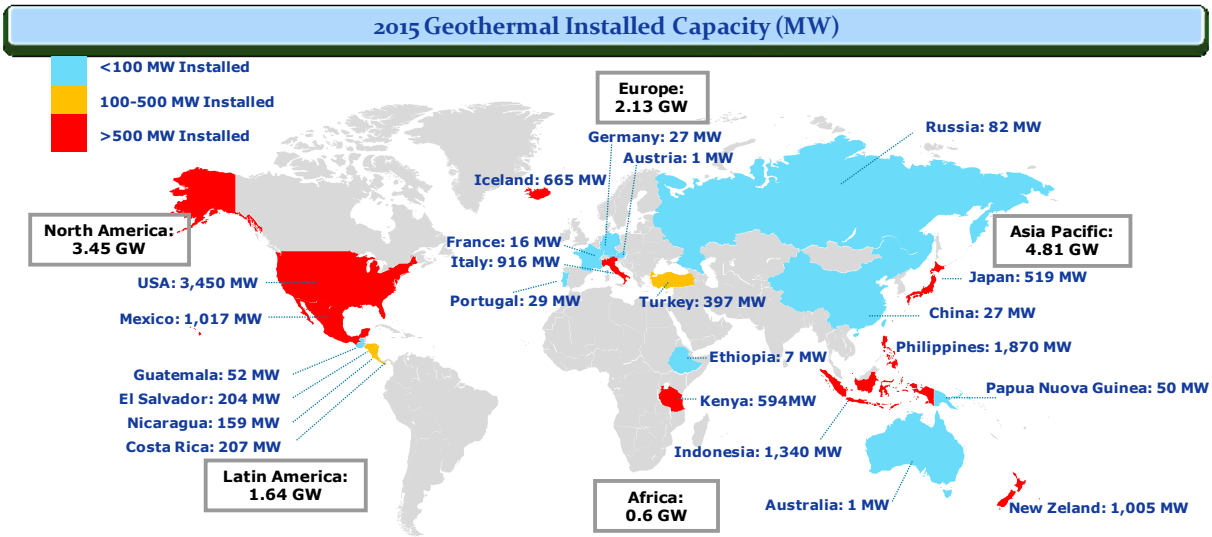

Figure 3: Installed capacity in 2015 worldwide [12.6 GWe].

In the following chapters 2, 3, 4 5 and 6 each continent has been analyzed through its countries. We have decided not to repeat again in this paper the detailed data for each geothermal field, already discussed in Bertani 2013, 2010, 2006.

We highlighted only the major achievement in the five years term since WGC2010. We are presenting here below all the countries with active geothermal plants for electricity generation, and also those with a not-negligible probability for some development for year 2020.

2. GEOTHERMAL POWER GENERATION: AMERICA

2.1 Argentina

During the last years, few advancances have been produced in most of the geothermal fields oriented to power generation. A potential evaluation of the Copahue geothermal field indicated that it could generate electricity, using the existing steam of approximately 1,200 m deep with a capacity of 30 MWe. Also in the Neuquén province was calling a public bid for private investors interested in building and operating a future plant for the generation of electrical power of 30 MWe, with an investment of 100 million US dollars. Other areas are currently under evaluation (Domuyo, Los Despoblados, Tuzgle-Tocomar, Peteroa and Los Molles and Termas de Río Hondo) (Pesce, 2015).

2.2 Bolivia

The Laguna Colorada field is under exploration phase. The possibility of a 40 MWe plant with expansion up to 100 MWe in the near future is realistic (Terceros, 2015).

2.3 Canada

Geothermal power generation has been explored for several years but policy limitations and the lack of adequate support is slowing any substantial progress towards a viable industry. It is estimated that over 5,000 MWe are available from shallow geothermal resources, including hot sedimentary aquifers, using current technology with an additional 10,000 MWe or more available in deep geothermal resources for future exploitation using enhanced geothermal systems. There are currently 6 active power generation projects developing in Canada (Canoe Reach, Lillocet, South Meager Creek, Rafferty, Pebble Creek, Lakelse) (Thompson, et al.,).

2.4 Caribbean

The eleven volcanic Eastern Caribbean islands comprise active thermal features, due to the westward subduction of the North Atlantic crustal plate beneath the Caribbean plate. Subsurface temperatures recorded in the region reach, in some case, more than 290°C. In Nevis, Nevis Renewable Energy International is performing geothermal exploration. The government of Dominica initiated the drilling of three exploratory slim holes with Icelandic Drilling Inc, confirming the existence of a commercially viable resource with temperatures up to about 240°C and a 10 MWe power plant, with an upscale up to 100 MWe, to be exported in Guadeloupe and Martinique through a submarine cable. In St. Lucia, the government signed a Memorandum of Agreement with UNEC Corporation for exploration and development in the Sulphur Springs region. In 2013, two wells were successfully drilled in Montserrat, with temperatures up to 298°C at a depth of 2,347 meters and the construction of a 5 MWe power plant is planned for completion by 2016 (work funded by the UK Department for International Development).Finally, Reykjavik Geothermal in St. Vincent and in Grenada, has initiated surface studies near the Soufriere Volcano on St. Vincent and GRENLEC, the Grenada utility is planning geothermal studies in the vicinity of Mt. St. Catherine (Huttrer and LaFleur, 2015).

2.5 Chile

Geothermal exploration in Chile has been very active in the last years, with about 14 private companies in 76 geothermal concession areas. Based on the results of these studies, eight exploitation concessions have been awarded, and in Apacheta and Tolhuaca, the results of environmental impact studies have been submitted for the development of power plant projects. The

University of Chile created the Andean Geothermal Centre of Excellence (CEGA), while the National Service of Geology and Mines is developing a basic geothermal research program (Lahsen, 2015).

2.6 Colombia

In Colombia there is not any geothermal development yet. Geothermal exploration studies being carried out by the Colombian Geological Survey, in Nevado del Ruiz, Tufiño – Chiles – Cerro Negro, Azufral, Paipa and San Diego area (Alfaro, 2015).

2.7 Costa Rica

Since the last WGC2010, geothermal development and exploration in the country have seen great development. The Miravalles Geothermal Field is continuing its productivity life (165 MWe) and the first unit of Las Pailas Geothermal Field has been commissioned in 2011 (42 MWe), and a second is planned, as well as in Borinquen and Pocosol. Geothermal energy continues to be a baseload for the electrical system in Costa producing 15% of the total electrical generation of the country (Sanchez-Rivera and Vallejos-Ruiz, 2015).

Development since WGC2010: Las Pailas, 42 MWe.

Costa Rica	Installed capacity 207 MWe	Geothermal Electricity 1,511 GWh/y

2.8 Ecuador

In the country a geothermal plan has been launched by MEER in 2010 for electricity generation, ranking 11 prospects for prefeasibility stage studies: Chachimbiro, Chalpatán, Chacana-Jamanco, Chalupas, Guapán, Chacana-Cachiyacu, Tufiño, Chimborazo, Chacana-Oyacachi, Baños de Cuenca and Alcedo. CELEC EP completed in 2012 geological, geochemical, and geophysical surveys at pre-drilling stage, including comprehensive MT and TDEM measurements for the Chachimbiro, Chacana-Cachiyacu and Chacana.-Jamanco prospects. An expected capacity of about 100 MWe has been evaluated (Beate and Urquizo, 2015).

2.9 El Salvador

In the country geothermal has been one of the main sources of electricity since the mid-1970s, and today the total installed capacity from geothermal resources in the country is 204 MWe, (Ahuachapán 95 MWe, Berlin 109 MWe) covering about 24% of the electricity needs with 13% of total installed capacity. The development plans of LaGeo (2015 – 2020), include a 28 MWe Unit 5 plus 5.7 MWe for the second bottoming binary cycle at Berlin and 5 MWe for the re-powering of Unit 2 at Ahuachapán geothermal field. LaGeo continues to develop geothermal projects in the areas of Chinameca and San Vicente, where the drilling exploratory stage confirmed a high enthalpy resource; and a power plant of 50 MWe and another of 30 MWe are planned to develop at the Chinameca and San Vicente geothermal fields respectively (Herrera, et al., 2010).

Development since WGC2010: no new plants commissioned.

El Salvador	Installed capacity 204 MWe	Geothermal Electricity 1,442 GWh/y

2.10 Guatemala

The geothermal accessible resource potential of Guatemala is about 1,000 MWe, as evaluated in several country assessment studies made by Unidad de Desarrollo Geotémico- Instituto Nacional del Electrificatión (UDG-INDE), with the identification of 14 promising areas, located in the Volcanic chain. Two geothermal fields, Zunil and Amatitán (28 and 24 MWe respectively) are currently under production, operated by INDE and Ormat through the controlled company Orzunil (Asturias and Grajeda, 2010).

Development since WGC2010: no new plants commissioned.

Guatemala	Installed capacity 52 MWe	Geothermal Electricity 237 GWh/y

2.10 Honduras

The geothermal potential of the country is significant, but it is not being exploited as a source of energy generation yet. Some development projects for electricity generation with geothermal resources are present, with identification of the presence of a moderate potential in six sites (Platanares, San Ignacio, Azacualpa, Sambo Creek, Puerto Cortes and Pavana) around the country for electricity generation (Henriquez, 2015).

2.11 Mexico

The geothermal installed capacity in the country is 1,017 MWe (839 MWe running) distributed into four geothermal fields in operation (Cerro Prieto 720 MWe, Los Humeros 94 MWe, Los Azufres 194 MWe and Las Tres Virgenes 10 MWe), owned and operated by the state utility CFE (Comisión Federal de Electricidad). Two additional geothermal projects are currently under construction: Los Azufres III with 50 MWe and Los Humeros III-A with 27 MWe. The production was about 6,100 GWh, representing 2.4% of the total electric output in the country. About 220 production wells were in operation producing 56 million of metric tons of steam and 67 million metric tons of brine, which is disposed of by a solar evaporation pond in Cerro Prieto and by 26 injection wells. Two permits for private developments have been issued for one small-production and one self-supplying project, both located in Nayarit. There are high expectations for the geothermal energy, due to a new regulatory framework and the foundation of a national geothermal innovation center (CEMIE-Geo)(Gutiérrez-Negrín, et al., 2015).

Development since WGC2010: two new units at Los Humeros 2x27 MWe.

Mexico	Installed capacity 1,017 MWe	Geothermal Electricity 6,071 GWh/y

2.12 Nicaragua

In Nicaragua geothermal studies started in the 60's, and an impressive geothermal potential of the country has been estimated (about 1,100 MWe), but only a minimal part have been exploited till now, covering approximately 10% of the national electricity consumption. There are five geothermal areas, with power plants only in two of them (Momotombo, 77 MWe and San Jacinto-Tizate 82 MWe) (Ruiz Cordero, 2015).

Development since WGC2010: 2x36 MWe units at San Jacinto-Tizate.

Nicaragua	Installed capacity 159 MWe	Geothermal Electricity 492 GWh/y

2.12 Peru

Peru has a great geothermal potential. Six geothermal regions have been identified in Peru. The most promising is the "Eje Volcánico Sur", where all the active volcanoes are located. The Japanese government supported the pre-feasibility studies in two fields, Calientes and Borateras, where 150 MWe were estimated. As a result on the new Geothermal Law, many private companies have looked into investing in Peru as a good opportunity to develop the geothermal resources, in more than 30 authorizations areas, most of them located in southern Peru (Cruz and Vargas, 2015).

2.13 USA

The present gross installed capacity for electric is 3,450 MWe with 2,542 MWe net (running), producing approximately 16,600 GWh per year. Geothermal electric power plants are located in California, Nevada, Utah and Hawaii with recent installations in Alaska, Idaho, New Mexico, Oregon, and Wyoming. In the last five years, about 350 MWe have been added. California is the most important state, with the two major productive poles of The Geysers and Imperial Valley. As a world record, the lowest temperature binary cycle using 74°C geothermal fluids is operating in Chena Hot Springs in Alaska, with three units for a total of 730 kWe. The first solar PV and thermal hybrid projects has been realized in Nevada, at Stillwater, where the 48 MWe geothermal plant is fully integrated with 26 MWe of PV panels and with 17 MWth of solar thermodynamic, with an additional output of 2 MWe. The production tax credit (of 2.0 cents/kWh) and the renewable portfolio standards are sustaining a growth rate of 3.6% per year. Geothermal energy remains, however, a small contributor to the electric power capacity and generation in the United States, with an estimated contribution of 0.48 % of the total generation (Boyd, et al., 2015).

USA	Installed capacity 3,450 MWe	Geothermal Electricity 16,600 GWh/y

2.13.1 Alaska

Development since WGC2010: no new plants commissioned.

USA-Alaska	Installed capacity 0.7 MWe	Geothermal Electricity 3.9 GWh/y

2.13.2 California

In California about 4.4% of the electricity generation came from geothermal power plants. In the state there are approximately 600 – 1,400 MWe of planned geothermal resource in various stages of development. The following geothermal fields are active in the state: Coso (292 MWe), East Mesa (126 MWe), Heber (236 MWe), Honey Lake (4 MWe), Hudson Ranch (50 MWe), Mammoth (40 MWe), Salton Sea (388 MWe), and The Geysers (1,584 MWe).

Development since WGC2010: a triple flash unit at Hudson Ranch, 50 MWe.

USA-California	Installed capacity 2,719 MWe	Geothermal Electricity 13,023 GWh/y

2.13.3 Hawaii

All the resources are at Puna, and the plants is delivering about 25% of the electricity on the big island.

Development since WGC2010: a new 8 MWe unit at Puna.

USA-Hawaii	Installed capacity 38 MWe	Geothermal Electricity 236 GWh/y

2.13.4 Idaho

Only the unit at Raft River is operative. The total geothermal potential for Idaho is 60 to 300 MWe.

Development since WGC2010: no new plant.

USA-Idaho	Installed capacity 16 MW	Geothermal Electricity 90.7 GWh/y

2.13.5 Nevada

Nevada is the most important state for the binary electricity production from geothermal fields, with 24 geothermal power plants with a total nameplate capacity of 576 MWe and with a total gross output of 3,500 GWh. The following geothermal fields are active in the state: Beowawe (20 MWe), Blue Mountain (50 MWe), Brady Hot Spring (26 MWe), Desert Peak (25 MWe), Dixie Valley (73 MWe), Don Campbell (16 MWe), Florida Canyon Mine (0.1 MWe), Jersey Valley (19 MWe), McGinnes Hills (52 MWe), Salt Wells (24 MWe), San Emidio (18 MWe), Soda Lake (23 MWe), Steamboat (133 MWe), Steamboat Hills (14 MWe), Stillwater (48 MWe), Tuscarora (32 MWe), and Wabuska (2 MWe). Nevada currently has 180 to 700 MWe of geothermal capacity in development.

Development since WGC2010: Tuscarora, McGinness Hills, San Emidio and Don A. Campbell for 134 MWe.

USA-Nevada	Installed capacity 576 MWe	Geothermal Electricity 3,456 GWh/y

2.13.6 New Mexico

In the country the first binary unit at Lightening Dock has been commissioned in 2014, with a planned addition up to 20 MWe.

Development since WGC2010: Lightening Dock for 4 MWe.

USA-New Mexico	Installed capacity 4 MWe	Geothermal Electricity n/a GWh/y

2.13.7 Oregon

In the state the electricity production has been increased at Neal Hot Spring, after the small plant of Klamath Falls. Overall there are 60 to 300 MWe of potential geothermal power capacity under development.

Development since WGC2010: Neal Hot Spring for 23 MWe.

USA-Oregon	Installed capacity 24 MWe	Geothermal Electricity n/a GWh/y

2.13.8 Utah

There are three productive fields: Cove Fort (26 MWe), Roosevelt (37 MWe) and Thermo Hot Spring (10 MWe).

Development since WGC2010: Cove Fort for 26 MWe.

USA-Utah	Installed capacity 73 MWe	Geothermal Electricity 387 GWh/y

2.13.9 Wyoming

Only a small pilot plant is in operation at Rocky Mountain Oilfield Testing Center.

Development since WGC2010: no new plant.

USA-Utah	Installed capacity 0.2 MWe	Geothermal Electricity 0.5 GWh/y

3. GEOTHERMAL POWER GENERATION: AFRICA

3.1 Algeria

The geothermal resources in Algeria are of low-enthalpy type, with the majority of the thermal springs (more than 240) located in the north of the country, with a heat discharge of 240 MWt. A small binary plant is planned at Guelma (Saibi, 2015).

3.2 Djibouti

Geothermal resources have been assessed in the country for 40 years, and several companies tried to exploit suitable sites, but without commercial success yet. The most promising area is the Asal field, where a project for a 50 MWe flash plant has been launched (Moussa and Souleiman, 2015).

3.3 Ethiopia

No activities have been performed in the country, and the geothermal development is still at the initial level of 1999, with a pilot plant at Aluto-Langano. The possibility of an expansion is under consideration, as well as a new plant at Tendao (Teklemariam, 2010).

Development since WGC2010: no new plant.

Ethiopia	Installed capacity 7.3 MWe	Geothermal Electricity 10 GWh/y

3.4 Kenya

The huge total geothermal potential of about 10 GWe of the country is currently under a very aggressive phase of development, with an impressive construction pipeline of new projects in several areas. All the high temperature prospects are located within the Kenya Rift Valley. The most important production pole is the Olkaria geothermal field (591 MWe), in exploitation since the first units in 1985, which has been recently expanded with about 300 MWe installed in the last two years. It is operated by Kenya Electricity Generating Company (KenGen) and Orpower. Moreover, the Oserian flower farm has a direct utilization of 10 MWth for heating greenhouses and an additional self-production of 4 MWe. A small unit is operating at Eburru (3 MWe). The Geothermal Development Company (GDC) is currently drilling at the Menengai geothermal field for the development of a 100 MWe project, (expected COD in 2015). Exploration is ongoing in Eburru, Suswa, Longonot, Baringo, Korosi, Paka, Silali and in Baringo – Silali, with a forecasting of 1,500 MWe in the near future (Omenda and Simiyu, 2015).

Development since WGC2010: 11 new units, for a total capacity of 390 MWe at Olkaria (I, II, III and IV) and Eburro.

Kenya	Installed capacity 594 MWe	Geothermal Electricity 2,848 GWh/y

4. GEOTHERMAL POWER GENERATION: ASIA

4.1 Armenia

The geothermal potential of the country is under evaluation, and a project of a flash unit at Jermaghbyur is ongoing.

4.2 China

In China the medium-low temperature geothermal direct uses are highly developed, whereas the electricity generation is still at a very early stage. Recently several institutions issued a document “Guidelines of Promoting Geothermal Energy Development and Utilization”, increasing geothermal survey and exploration with both state-owned and private enterprises. With the conclusion of the construction of Yangyi power plant, the total capacity of the country will be doubled, with all the operative units located in Tibet (Yangbajain and Yangyi) (Zheng,et al., 2015).

Development since WGC2010: 3 new units, for a total capacity of 3 MWe in Tibet.

China	Installed capacity 28 MWe	Geothermal Electricity 155 GWh/y

4.3 India

Geothermal electricity is not present in India; a first project in Gujarat using abandoned oil wells is under evaluation (Chandrasekharam and Chandrasekhar, 2015).

4.4 Indonesia

Geothermal resources in the country are associated with volcanoes along Sumatra, Java, Bali and the islands in eastern part of Indonesia, with an expected potential of about 28 GWe composed of 312 geothermal potential locations. The current geothermal fields are operated from 10 locations: Darajat (260 MWe), Dieng (60 MWe), Kamojang (200 MWe), Gunung Salak (377 MWe), Sibayak (11 MWe), Lahendong (87 MWe), Wayang Windu (227 MWe), Ulu Belu – South Sumatra (110 MWe), Ulumbu – Flores (5 MWe) and Mataloko (2.5 MWe). The installed electrical capacities consist of 1,340 MWe, with short-medium term development for the year 2025 of about 6,000 MWe (correspondingly to 5% of the energy needs of the country). About 440 MWe are in advanced construction stage in five plants at Sarulla and Lumut-Balai (Darma and Gunawan, 2015).

Development since WGC2010: 3 new areas (Ulumbu, Mataloke and Ulubelu), for a total additional capacity of 143 MWe.

Indonesia	Installed capacity 1,340 MWe	Geothermal Electricity 9,600 GWh/y

4.5 Iran

The potential of geothermal energy in Iran is large in terms of moderate, low and someway also for high temperature. At the moment, projects assuming 5 MWe of geothermal power plants are underway, in the most promising (Sabalan) of the 14 suitable regions for geothermal activities (Porkhial and Yousefi, 2015).

3.6 Japan

Despite the large geothermal potential of the country, estimated about 20 GWe, the present total capacity of geothermal power plant is still around 500 MWe, almost unchanged for more than a decade. After the nuclear accident in March 2011, the government re-started an incentive scheme for geothermal development and mitigation of constraints in national parks, encouraging new geothermal exploration activities by private sectors as well as quick installation of small binary systems. About 40 projects are under exploration or development. The following fields are active: Akita (88 MWe), Fukushima (65 MWe), Hachijojima (3 MWe), Hokkaido (25 MWe), Iwate (103 MWe), Kagoshima (60 MWe), Kumamoto (2 MWe), Miyagi (15 MWe), Oita (155 MWe), and Tokamachi (2 MWe) (Yasukawa and Sasada, 2015).

Development since WGC2010: no major projects; derating the unit of Mori from 50 to 25 MWe.

Japan	Installed capacity 519 MWe	Geothermal Electricity 2,687 GWh/y

4.7 Philippines

A new law provides fiscal and non-fiscal incentives to promote and accelerate the exploration, development and utilization of renewable energy resources which include geothermal energy. As a consequence, 43 Geothermal Service/Operating Contracts has been awarded, expecting an additional capacity of 20 MWe at Maibarara and 30 MWe at Nasulo projects to be commissioned by 2014. Likewise, expansion and optimization projects are in the pipeline. With the current installed capacity of 1,870 MWe geothermal contributes to 14% of the total electricity requirements, from 7 productive poles (Bacon-Manito/Sorsogon/Albay 131 MWe, Mak-Ban/Laguna 458 MWe, Mindanao/Mount Apo 108 MWe, Palinpinon/Negros Oriental 192 MWe, Tiwi/Albay 234 MWe, Maibarara 20 MWe and Tongonan/Leyte 726 MWe (Fronda, et al., 2015).

Development since WGC2010: no major projects, decommissioning of Northern Negros (50 MW), commissioning 20 MWe at Maibarara in 2014.

Philippines	Installed capacity 1,870 MWe	Geothermal Electricity 9,646 GWh/y

4.8 Taiwan

Taiwan possesses rich geothermal resources due to volcanic activities and plate collision, with an estimated potential of 150 GWe of potential geothermal energy, still untapped (only a small binary unit is in operation). Four hot potential sites have been recognized. More detailed geothermal surveys are ongoing, and a pilot geothermal plant of 1 MWe is planned (Tsanyao, 2015).

Development since WGC2010: a new small binary unit at Chingshui in 2012.

Taiwan	Installed capacity 0,05 MWe	Geothermal Electricity 0,04 GWh/y

4.9 Thailand

Geothermal resources in Thailand are classified into low-medium enthalpy, with suitable possibilities for small scale power plant, in the range 1-10 MWe with binary technology. Currently, geothermal utilization as binary cycle power plant is 0.3 MWe (Raksaskulwong, 2015).

Development since WGC2010: no new plants.

Thailand	Installed capacity 0.3 MWe	Geothermal Electricity 1.2 GWh/y

5. GEOTHERMAL POWER GENERATION: EUROPE

5.1 Austria

No new activity for electricity generation has been conducted in the country. An old plant (Simbach-Braunau) was decommissioned (Goldbrunner, 2015).

Development since WGC2010: non new plants since WGC2010 a small unit decommissioned.

Austria	Installed capacity 1.2 MWe	Geothermal Electricity 2.2 GWh/y

5.2 Czech Republic

The geothermal energy use in the Czech Republic has been constantly increasing, focusing on district heating. Only one cogeneration geothermal project – in Litomerice – has been already under development (Jirakova, et al., 2015).

5.3 France

France has defined ambitious objectives for electrical geothermal development, but limited to the overseas territory (Guadalupe, in Caribbean Sea); many projects are emerging on the mainland (combined heat and power). The first 1.5 MWe EGS pilot plant at Soultz-sous-Forêts is fully operative (Vernier, et al., 2015).

Development since WGC2010: non new plants since WGC2010.

France	Installed capacity 16 MWe	Geothermal Electricity 115 GWh/y

5.4 Germany

In the country only Organic Rankine and Kalina cycle techniques are applied, mainly in conjunction with district heating system, for geothermal power production, due to the lack of high enthalpy resources at shallow depth. Several new 5 MWe power plants have been commissioned, resulting in a total installed capacity of 27.1 MWe in Germany. the Federal Government is supporting the geothermal development through funding R&D projects and with the very generous new feed-in tariff, increased to 0.25 €/kWh. The majority of the projects is in Bayern (20 MWe) and Rheinland-Pfalz (7 MWe) (Weber, et al., 2015).

Development since WGC2010: 20 MWe in four new units: Dürrnhaar, Kirchstockach, Insheim and Sauerlach.

Germany	Installed capacity 27 MWe	Geothermal Electricity 35 GWh/y

5.5 Greece

Greece is rich in geothermal resources, but unfortunately no geothermal electricity is produced in Greece, despite the fact that a pilot 2 MWe power plant was built and operated in the 1980s in Milos Island. Several projects are in evaluation phase (Andritsos, et al., 2015).

5.6 Hungary

Hungary's excellent geothermal potential is well-known, with important development for direct heat supply (mostly for the thermal water used in spas). As yet, there is no operational geothermal power-plant in Hungary. Many projects are currently being prepared (Toth, 2015).

5.7 Iceland

The country's geological characteristics (its location on the Mid-Atlantic Ridge) are favoring the large utilization of geothermal energy in the energy supply of Iceland. The share of geothermal energy in the primary energy supply of Iceland is about 68%, reaching 90% of all energy used for house heating. Geothermal electricity generation started 45 years ago and has now reached 29% of the total electricity needs. The total installed capacity is now above 650 MWe and the annual generation about 5,250 GWh, from the following fields: Námafjall 3 MWe, Hellisheidi 303 MWe, Húsavík 2 MWe, Krafla 60 MWe, Nesjavellir 120 MWe, Reykjanes 100 MWe and Svartsengi 76 MWe (Ragnarsson, 2015).

Development since WGC2010: 90 MWe of two new units at Hellisheidi IV.

Iceland	Installed capacity 665 MWe	Geothermal Electricity 5,245 GWh/y

5.8 Italy

The geothermal resources for electricity generation are located in Tuscany, in the two historical areas of Larderello-Travale (795 MWe) and Mount Amiata (121 MWe). The gross electricity generation reached 5,700 GWh, the new record of electricity produced from geothermal resource in Italy. Several old units have been decommissioned and replaced with new ones, and a new two-unit power plant at Bagnore IV has been commissioned. The first binary power plant in Italy (Gruppo Binario Bagnore3 – 1 MWe) has been realized, on the liquid separated stream from the primary flash; finally at Cornia 2 a first hybrid project with a biomass heater has been launched, increasing the output power from 12 MWe to 17 MWe (Razzano and Cei, 2015).

Development since WGC2010: 74 MWe from two new units at Mount. Amiata and three at Larderello (with some decommissioning of old plants).

Italy	Installed capacity 916 MWe	Geothermal Electricity 5,660 GWh/y

5.9 Latvia

There is no operational geothermal power-plant in Latvia, but a small binary pilot plant project is under evaluation.

5.10 Netherland

There is no operational geothermal power-plant in Netherland, but a small binary pilot plant project is under evaluation (Van Heekeren and Bakema, 2015).

5.11 Poland

The geothermal potential of the country is well known, with important development for direct heat supply. As yet, there is no operational geothermal power-plant in Poland, but a small binary pilot plant at Lodz is under evaluation (Kępińska, 2015).

5.12 Portugal

The high temperature geothermal resources are restricted to the volcanic islands of Azores Archipelago, with operating plants at S. Miguel Island (Ribeira Grande Geothermal Field) and advanced project in Terceira Island (Pico Alto Geothermal Field). Power production from geothermal resources in Azores presently meets 42% of the electrical consumption of S. Miguel, and over 22% of the total demand of the archipelago (Carvalho, et al., 2015).

Development since WGC2010: no new plants.

Portugal	Installed capacity 29 MWe	Geothermal Electricity 196 GWh/y

5.13 Romania

The geothermal potential of the country is large, with important development for direct heat supply. In 2012, Transgex S.A. installed the first power generation unit in Romania: 50 kWe unit, using 10 l/s of 105°C geothermal water at Oradea (Bendea, et al., 2015).

Development since WGC2010: a small binary unit at Oradea.

Romania	Installed capacity 0,1 MWe	Geothermal Electricity 0,4 GWh/y

5.14 Russia

There are several areas of the country with a good geothermal potential, in the European part of Russia: Central region; Northern Caucasus; Daghestan; in Siberia: Baikal rift area, Krasnoyarsk region, Chukotka, Sakhalin. Kamchatka Peninsula and the Kuril Islands, with an overall evaluation of about 2000 MWe of electricity and for more than 3000 MWe of heat for district heating system. Several combined heat and electricity projects are ongoing. The installed plants are in Kamchatka (Pauzhetskaya 14 MWe, Verkhne-Mutnovskaya 12 MWe and Mutnovskaya 50 MWe) and Kuril islands (Iturup 4 MWe and Kunashir 2 MWe) (Svalova and Povarov, 2015).

Development since WGC2010: no new units.

Russia	Installed capacity 82 MWe	Geothermal Electricity 440 GWh/y

5.15 Slovakia

Geothermal waters are widely used for recreational purposes, mostly in very popular aqua parks in many places of Slovakia, with several others direct utilization. A small pilot plant is under evaluation at Kosice, for a combined heat and electricity project (Fendek and Fendekova, 2015).

5.16 Spain

At present, there is no geothermal power generation in Spain, despite the good potential in the Canarias islands and the favorability of the Spanish geological setting for EGS type projects (Arrizabalaga, et al, 2015).

5.17 Switzerland

Direct use of geothermal energy is a success story in Switzerland, with all the standard utilization, from the oldest thermal spas, to heating residential and apartment houses, office buildings, agricultural sector and so on. The cooling application is becoming more and more important. Even tunnel water is alternately used for heating and cooling. Deep geothermal energy for power production is not applied, and no power has been produced yet. A small pilot plant is planned at St. Gallen (Link, et al., 2015).

5.18 Turkey

A significant development was achieved in Turkey in geothermal electricity production and direct uses (district, greenhouse heating and thermal tourism) during last five years, also due to the new Geothermal Law, its regulations and the feed in tariff. About 225 geothermal fields have been discovered in Turkey, and today electricity production has reached almost 400 MWe, with more than 350 MWe of new plants. A liquid carbon dioxide and dry ice production factory is integrated to the Kizildere geothermal power plant. The existing plants are in the following areas: Çanakkale-Tuzla 7 MWe, Aydin-Hidirbeyli 68 MWe, Aydin-Salavath 35 MWe, Aydin-Germencik 98 MWe, Aydin-Gümüsköy 7 MWe, Denizli-Kizildere 107 MWe, Aydin-Pamukören 48 MWe, Manisa-Alasheir 24 MWe, Denizli-Gerali 3 MWe) (Mertoglu, et al., 2015).

Development since WGC2010: in impressive amount of new units, for a total of about 350 MWe.

Turkey	Installed capacity 397 MWe	Geothermal Electricity 3,127 GWh/y

5.19 UK

The exploitation of geothermal resources in the UK continues to be minimal, due to the lack of high temperature resources and the limited development of low and medium enthalpy resources. However, two EGS/HDR projects in Cornwall have sites and planning approval (Batchelor, et al., 2015).

6. GEOTHERMAL POWER GENERATION: OCEANIA

6.1 Australia

In Australia three deep wells were completed, and after 20 years a new geothermal power plant (1 MWe Habanero Pilot Plant) has been commissioned. Unfortunately, many of the companies involve in geothermal exploration are leaving the sector, and the number exploration licenses is decreasing (Beardsmore, et al., 2015).

Development since WGC2010: a new plant at Habanero.

Australia	Installed capacity 1.1 MWe	Geothermal Electricity 0.5 GWh/y

6.2 New Zealand

New Zealand is in a phase of impressive growing for geothermal electricity generation, due to the availability of high temperature, productive geothermal resources associated with lowest cost for electricity generation facilities compared to other renewable energy or fossil-fuelled options. Geothermal electricity generation capacity is contributing about 16% of the national electricity generation (c.f. 13% in 2010) in an electricity system dominated by renewable generation (75% of its electricity from renewable energy sources). The productive areas are all in the Taupo volcanic zone, at Wairakei 399 MWe, Kawerau 140 MWe, Reporoa 57 MWe, Rotokawa 167 MWe, Ngawha 25 MWe, Mokai 111 MWe, Tauhara 24 MWe and Ngatamariki 82 MWe (Carey, et al., 2015).

Development since WGC2010: 243 MWe of new plants, in Ngatamariki, Tauhara and Wairakeie.

New Zealand	Installed capacity 1,005 MWe	Geothermal Electricity 7,000 GWh/y

6.3 Papua-New Guinea

Papua New Guinea is located within the "ring of fire", with has numerous active volcanoes and known geothermal systems. There are currently 50 MWe (gross) of geothermal power installed at Lihir Gold Mine. The high cost of diesel and fuel oil, and the unpredictable nature of hydro power stations, has renewed strong interest in geothermal power (Kuna and Zehner, 2015).

Development since WGC2010: no new plants since WGC2010 a small unit decommissioned.

Papua New Guinea	Installed capacity 50 MWe	Geothermal Electricity 432 GWh/y

7. STATISTICAL HIGHLIGTHS

7.1 Some Ranking

Top Five

The "Top Five Countries" for capacity and produced energy are in the following table IV:

Table IV: Top five countries for installed capacity in 2015.

COUNTRY	2010 MWe	2010 GWh	2015 MWe	2015 GWh
USA	3,098	16,603	**3,450**	16,600
PHILIPPINES	1,904	10,311	**1,870**	9,646
INDONESIA	1,197	9,600	**1,340**	9,600
MEXICO	958	7,047	**1,017**	6,071
NEW ZEALAND	762	4,055	**1,005**	7,000

It should be mentioned the important change of ranking of New Zealand, (now 5th). Italy is now downgraded to the 6th position.

The "Top Five Countries" for absolute value increase are highlighted as follows in table V:

Table V: Top five countries for the absolute increase in MWe since WGC2010.

COUNTRY	MWe	GWh	%MWe	%GWh
KENYA	**392**	1.418	194%	99%
USA	**352**		11%	
TURKEY	**306**	2.637	336%	539%
NEW ZEALAND	**243**	2.945	32%	73%
INDONESIA	**143**		12%	

Kenya and Turkey are two most important achievements: geothermal electricity has been in a long stagnant phase, since the early development, and nowadays it is rising very quickly and toward an impressive growing target.

Moreover, USA, Indonesia, and New Zealand represent an important signal: even in countries where the geothermal development started more than 50 year ago, still the industry is presently proactive in launching new projects, and the economical environment is strongly positive in terms of incentives and supporting measures.

The "Top Five Countries" for percentage increase are the following (table VI):

Table VI: Top five countries for the % increase in MWe since WGC2010.

COUNTRY	MWe	GWh	%MWe	%GWh
TURKEY	306	2.637	**336%**	539%
GERMANY	20		**280%**	
KENYA	392	1.418	**194%**	99%
NICARAGUA	72	182	**82%**	59%
NEW ZEALAND	243	2.945	**32%**	73%

The value of Turkey is impressive, for its relative large installed capacity. Germany is big, but mainly due to its very small starting value. On the other hand, Kenya, Nicaragua and New Zealand are important geothermal countries with a significant relative increase in the last five years.

7.2 Plant Classification

We followed the standard plant classification with the classical definitions of binary, back pressure, single/double flash and dry steam plant. In the pie charts of figures 4, 5 and 6 the installed capacity in MWe, the produced energy in GWh and the total number of units for each category is presented.

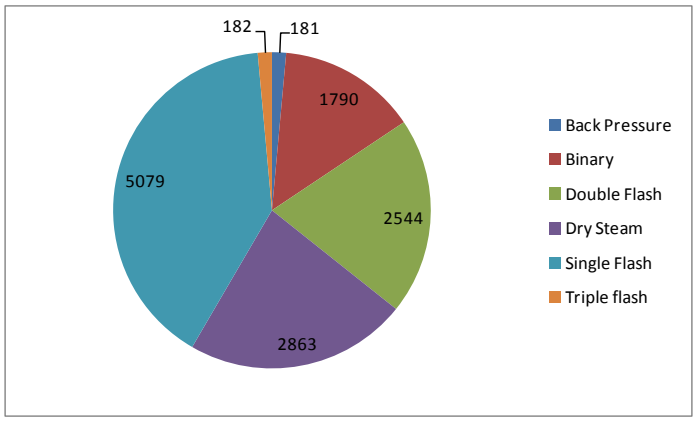

Figure 4: Installed capacity in MWe for each plant typology (total 12,6 GWe) .

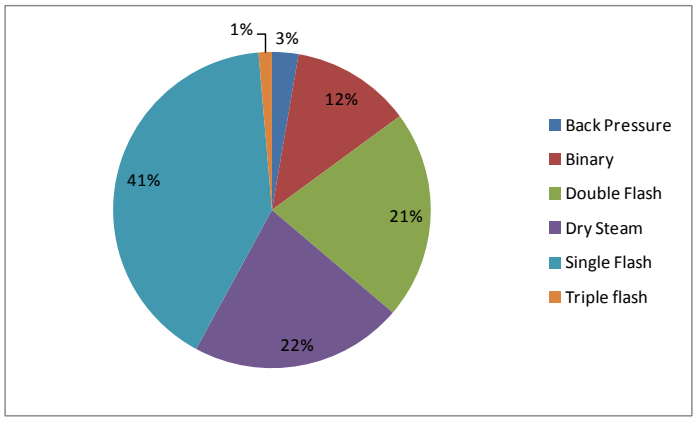

Figure 5: Produced energy in % from each plant typology.

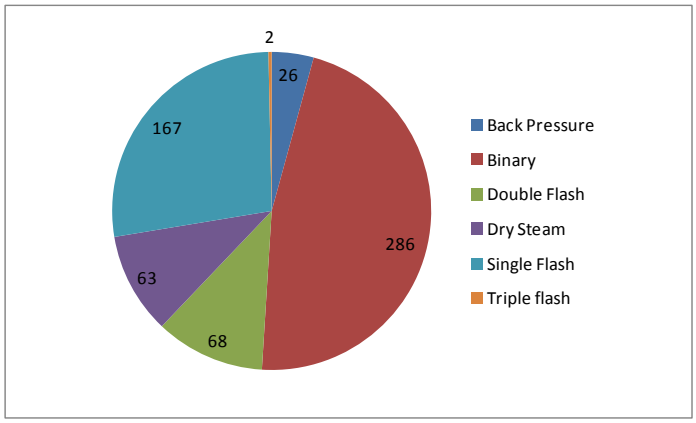

Figure 6: Number of units for each typology (total 613).

We have evaluated the distribution per country and per continent of the individual plant characteristic, accounting the installed capacity. Results are shown in tables VII and VIII.

Table VII: Plant category per continent (Installed Capacity, MWe).

Country	Back Pressure	Binary	Double Flash	Dry Steam	Hybrid	Single Flash	Triple flash	TOTAL
Africa	48	11				543		602
Asia		236	525	484		2514		3758
Europe		268	273	795		796		2133
Latin America	90	135	510			908		1642
North America		873	881	1584	2	60	50	3450
Oceania	44	266	356			259	132	1056
TOTAL	**181**	**1790**	**2544**	**2863**	**2**	**5079**	**182**	**12640**

Table VIII: Plant category per country (Installed Capacity, MWe).

Country	Back Pressure	Binary	Double Flash	Dry Steam	Hybrid	Single Flash	Triple flash	TOTAL
Australia		1						1
Austria		1						1
China		3	24			1		28
Costa Rica	5	63				140		208
El Salvador		9	35			160		204
Ethiopia		7						7
France		2	5			10		16
Germany		27						27
Guatemala		52						52
Iceland		10	90			564		665
Indonesia		8		460		873		1340
Italy		1		795		120		916
Japan		7	135	24		355		520
Kenya	48	4				543		594
Mexico	75	3	475			466		1019
New Zealand	44	265	356			209	132	1005
Nicaragua	10	8				142		160
Papua New Guinea						50		50
Philippines		219	365			1286		1870
Portugal		29						29
Romania		0						0
Russia						82		82
Taiwan		0						0
Thailand			0					0
Turkey		198	178			20		397
USA		873	881	1584	2	60	50	3450
TOTAL	**181**	**1790**	**2544**	**2863**	**2**	**5079**	**182**	**12640**

The average values per unit of the installed capacity and the produced energy is given in table IX.

Table IX: Average capacity and energy per each plant category (hybrid excluded).

TYPE	Average Energy (GWh/ unit)	Average Capacity (MWe/unit)
Binary	31	6.3
Back Pressure	76	7.0
Single Flash	179	30.4
Double Flash	231	37.4
Triple Flash	500	90.8
Dry Steam	253	45.4

Finally, in the table X the list of all the new installed plant is presented.

Table X: The new plants list.

Country:	Plant	Unit	COD	Type	Manufacturer	Capacity (MWe)	Operator
Japan	Oguni Matsuya	1	2015	binary		0.06	
Indonesia	Ulu Belu	1	2014	Single Flash	Toshiba	55	PLN
Indonesia	Ulu Belu	2	2014	Single Flash	Toshiba	55	PLN
Italy	Bagnore 4	2	2014	Single Flash	Ansaldo_Tosi	20	Enel Green Power
Italy	Bagnore 4	1	2014	Single Flash	Ansaldo_Tosi	20	Enel Green Power
Japan	Yumura Spring	1	2014	binary		0.03	
Japan	Hagenoyu	3	2014	binary		2	
Japan	Shichimi Spring	1	2014	binary		0.02	
Japan	Goto-en	2	2014	binary		0.09	
Japan	Beppu Spring	4	2014	binary		0.5	
Kenya	Olkaria I	4	2014	Single Flash	Toyota	70	KenGen
Kenya	Olkaria I	5	2014	Single Flash	Toyota	70	KenGen
Kenya	Olkaria III	3a	2014	Single Flash	ORMAT	13	ORMAT
Kenya	Olkaria III	3b	2014	Single Flash	ORMAT	13	ORMAT
Kenya	Olkaria IV	1	2014	Single Flash	Toyota	70	KenGen
Kenya	Olkaria IV	2	2014	Single Flash	Toyota	70	KenGen
Kenya	WellHEad OW43	1	2014	Back Pressure	Elliot	12.8	Oserian Development
Kenya	WellHEad	1	2014	Back Pressure	Elliot	30	Oserian Development
New Zealand	Te Mihi	1	2014	Double Flash	Toshiba	83	Contact Energy

Table X: The new plants list.

Country:	Plant	Unit	COD	Type	Manufacturer	Capacity (MWe)	Operator
New Zealand	Te Mihi	2	2014	Double Flash	Toshiba	83	Contact Energy
Philippines	Maibarara	1	2014	Single Flash	Fuji	20	Maibarara Geothermal
Turkey	Dora	3b	2014	Binary	ORMAT	9	MENDERES
Turkey	Degirmenci	1	2014	Binary		2.5	Turcas Güney Elektrik
Turkey	Alasheir	1	2014	Binary	ORMAT	24	Turkeler
USA	Lightening Dock	2	2014	Binary		4	Raser Technologies
USA	Don Campbell	1	2014	Binary	ORMAT	16	ORMAT
Australia	Habanero	1	2013	Binary	Peter Brotherhood	1	Geodynamics
Germany	Dürrnhaar	1	2013	Binary	UTC_Turboden	5.6	Municipality Germany
Germany	Kirchstockach	1	2013	Binary	UTC_Turboden	5.6	Municipality Germany
Germany	Insheim	1	2013	Binary	UTC_Turboden	4.3	Municipality Germany
Indonesia	Mataloko	1	2013	Single Flash	Fuji	2.5	PLN
Japan	Abo-tunnel	1	2013	binary		0.003	
Kenya	WellHEad OW37	1	2013	Back Pressure	Elliot	5	Oserian Development
Mexico	Los Humeros II	B	2013	Single Flash	Alstom	27	Comisión Federal de
New Zealand	Ngatamariki	1	2013	Binary	Ormat	20.5	Mighty River Power
New Zealand	Ngatamariki	2	2013	Binary	Ormat	20.5	Mighty River Power
New Zealand	Ngatamariki	3	2013	Binary	Ormat	20.5	Mighty River Power
New Zealand	Ngatamariki	4	2013	Binary	Ormat	20.5	Mighty River Power
New Zealand	Te Huka	1	2013	Binary	Ormat	12	Contact Energy
New Zealand	Te Huka	2	2013	Binary	Ormat	12	Contact Energy
Nicaragua	San Jacinto-Tizate	4	2013	Single Flash	Fuji	36	Ram Power
Turkey	Germencik	2	2013	Double Flash	Mitsubishi	51	GURMAT
Turkey	Gümüsköy	1	2013	Binary	TAS	6.6	BM
Turkey	Pamukören	1	2013	Binary	Atlas-Copco	24	Çelikler Jeotermal Elektrik
Turkey	Pamukören	2	2013	Binary	Atlas-Copco	24	Çelikler Jeotermal Elektrik
Turkey	Kizildere	2	2013	Double Flash	Fuji	80	ZORLU
USA	EGS	1	2013	Binary	ORMAT	1.7	ORMAT
USA	Cove Fort	B1	2013	Binary	ORMAT	13	Enel Green Power
USA	Cove Fort	B2	2013	Binary	ORMAT	13	Enel Green Power
Germany	Sauerlach	1	2012	Binary	UTC_Turboden	5	Municipality Germany
Indonesia	Ulumbu	1	2012	Single Flash	Fuji	2.5	PLN
Indonesia	Ulumbu	2	2012	Single Flash	Fuji	2.5	PLN
Indonesia	Lahendong	B1	2012	Binary		7.5	BPPT
Indonesia	Lahendong	4	2012	Single Flash	Fuji	20	BPPT
Italy	Bagnore Binary	1	2012	Binary	Exergy	1	Enel Green Power
Japan	Niigata	1	2012	Binary	EcoGen	2	Wasabi
Mexico	Los Humeros II	A	2012	Single Flash	Alstom	27	Comisión Federal de
New Zealand	Kawerau -Topp	1	2012	Binary	ORMAT	23	Norske Skog Tasman
Nicaragua	San Jacinto-Tizate	3	2012	Single Flash	Fuji	36	Ram Power
Romania	Oradea	1	2012	Binary	UTC_Turboden	0.05	null
Taiwan	Qingshui	2	2012	Binary		0.05	null
Turkey	DENIZ	1	2012	Binary	ORMAT	24	MAREN
Turkey	SINEM	1	2012	Binary	ORMAT	24	MAREN
Turkey	Dora	3a	2012	Binary	ORMAT	9	MENDERES
USA	Hudson Ranch I	1	2012	Triple Flash	Fuji	49.5	EnergySource
USA	Florida Canyon Mine	1	2012	Binary		0.1	Electratherm
USA	McGinness Hill	1	2012	Binary	ORMAT	52	ORMAT
USA	San Emidio	1	2012	Binary	Turbine Air System	12.75	US Geothermal
USA	Tuscarora	1	2012	Binary	ORMAT	32	ORMAT
USA	Neal	1	2012	Binary		23	US Geothermal
China	Yangyi	1	2011	Single Flash		0.9	Jiangxi Huadian Electric
Costa Rica	Las Pailas	1	2011	Binary	ORMAT	21	Instituto Costarricense de
Costa Rica	Las Pailas	2	2011	Binary	ORMAT	21	Instituto Costarricense de
Iceland	Hellisheidi IV	1	2011	Single Flash	Mitsubishi	45	Orkuveita Reykjavikur
Iceland	Hellisheidi IV	2	2011	Single Flash	Mitsubishi	45	Orkuveita Reykjavikur

Table X: The new plants list.

Country:	Plant	Unit	COD	Type	Manufacturer	Capacity (MWe)	Operator
Italy	Nuova Radicondoli	2	2011	Dry Steam	Ansaldo Tosi	20	Enel Green Power
Kenya	Eburro	1	2011	Single Flash	Elliot	2.5	KenGen
Turkey	IREM	1	2011	Binary	ORMAT	20	MAREN
USA	Puna	11	2011	Binary	ORMAT	8	ORMAT
USA	Beowave	2	2011	Binary	Turbine Air System	1.9	Beowawe Power
USA	Dixie Valley	2	2011	Binary	Turbine Air System	6.2	Terra Gen
China	North Oil Field	1	2010	Binary		0.4	
China	Longyuan	2	2010	Binary		1	Longyuan Co
Italy	Chiusdino 1	1	2010	Dry Steam	Ansaldo_Tosi	20	Enel Green Power
Kenya	Olkaria II	3	2010	Single Flash	Mitsubishi	35	KenGen
New Zealand	Nga Awa Purua	1	2010	Triple flash	Fuji	132	Mighty River Power
Turkey	Dora	2	2010	Binary	ORMAT	9.5	MENDERES
Turkey	Tuzla	1	2010	Binary	ORMAT	7.5	Dardanel
USA	Jersey Valley	1	2010	Binary	ORMAT	19.4	ORMAT

7.3 Manufacturer and Operator Ranking

The Turbine manufacturer for the plant currently in operation are presented figure 7. It is surprisingly to have at the first position Japanese companies, whereas in Japan construction of geothermal plants is practically halted.

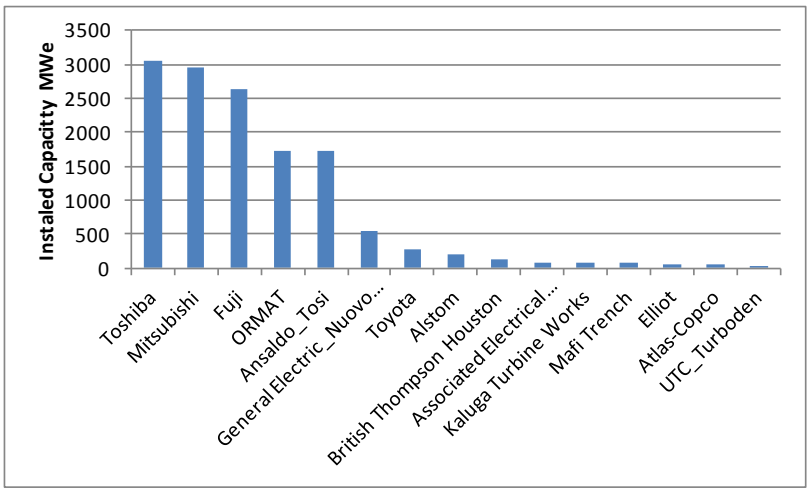

Figure 7: The most important geothermal Turbine manufacturer.

In figure 8 the geothermal field operator active in the present development are presented.

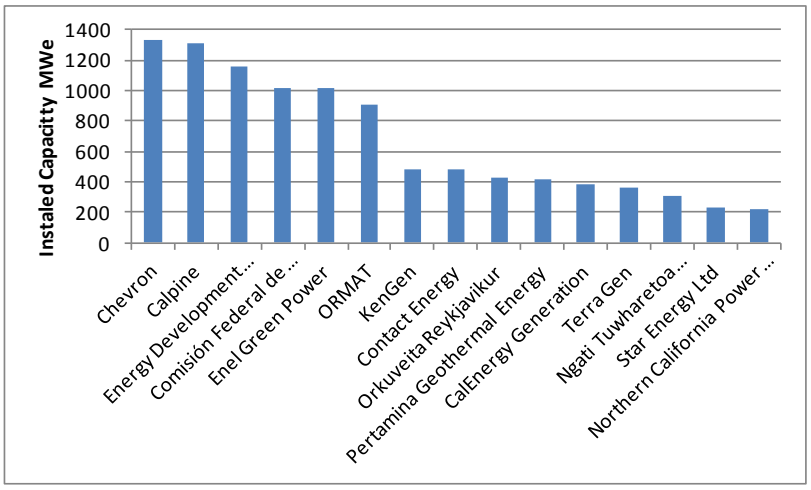

Figure 8: The most important geothermal field operators.

5. CONCLUSION

The present value of 12.6 GW is an important result, confirming the trend started in 2010, above the 10 GW threshold toward a second exponential growing phase, mainly from the increasing in the medium-low temperature development projects through binary plants, and an important effort in realizing all the economically viable projects worldwide. The short term forecasting for 2020 is an hope: the expected 21 GWe is on the exponential behavior forecasting. Now it would be important to transform 8 GWe of paper-projects in real plants in five years. This challenge will be able to give to the entire geothermal community a clear signal of the possibility and the willingness of being one of the most important renewable energy player in the future electricity market.

We have evaluated (Bertani, 2003) the expected geothermal targets for year 2050:

- from hydrothermal resources of 70 GWe :
- 140 GWe in total (with EGS and other non conventional resources)

If the target of 140 GW will be reached, it would be possible to produce from geothermal up 8.3% of total world electricity production, serving 17% of world population. Moreover, 40 countries (located mostly in Africa, Central/South America, Pacific) can be 100% geothermal powered. The overall CO_2 saving from geothermal electricity can be in around 1,000 million tons per year.

The estimated value of 21 GWe for 2020 is in line with the long term forecasting for standard hydrothermal fields.

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