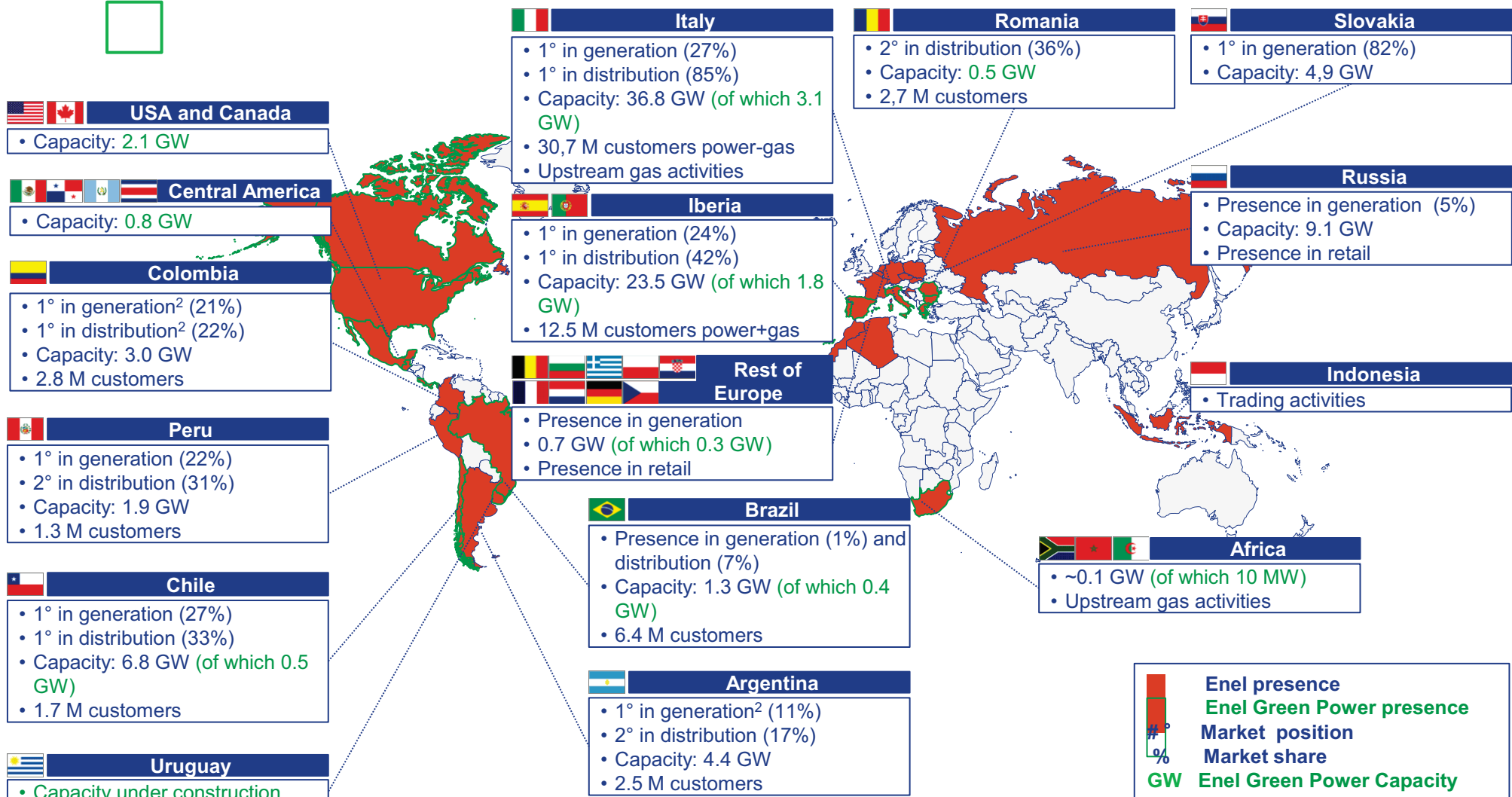


# The geothermal energy in the world: present situation and outline

Ruggero Bertani  
Geothermal Innovation & Sustainability  
Enel Green Power  
Trieste, December 2015



# Enel's global presence<sup>1</sup>



**Global diversified player in more than 30 countries**

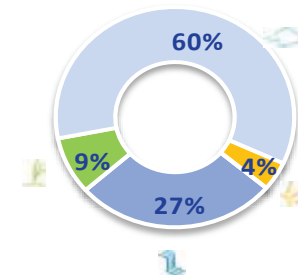
1. As of 31<sup>st</sup> December 2014  
2. Among private operators



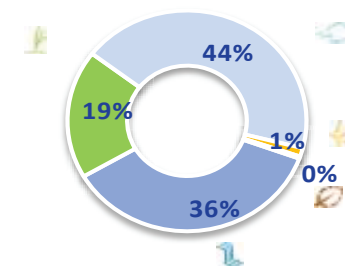
# Global leadership in RES development FY 2014



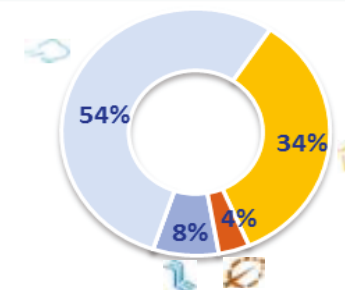
Installed Capacity = 9,6 GW



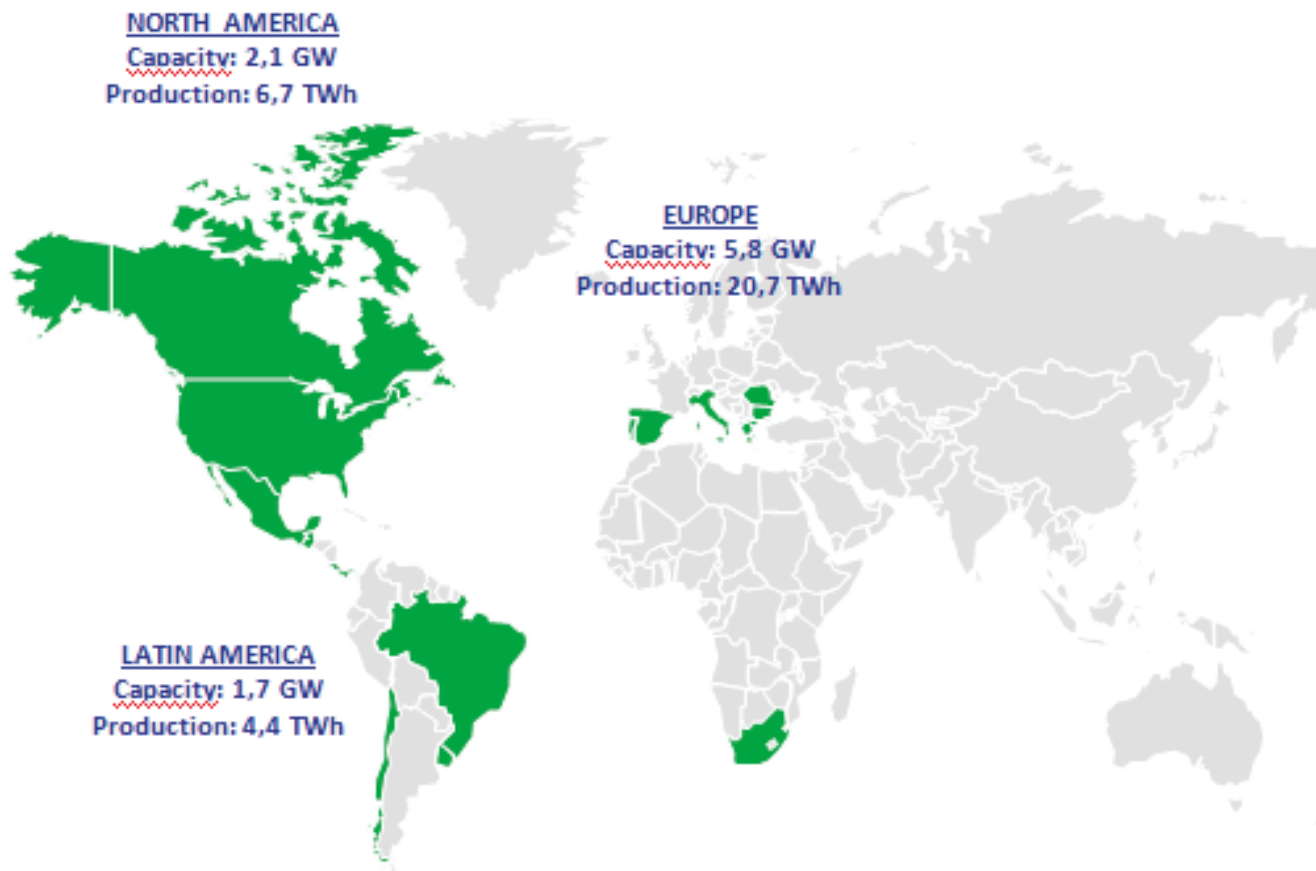
Production = 31,8 TWh



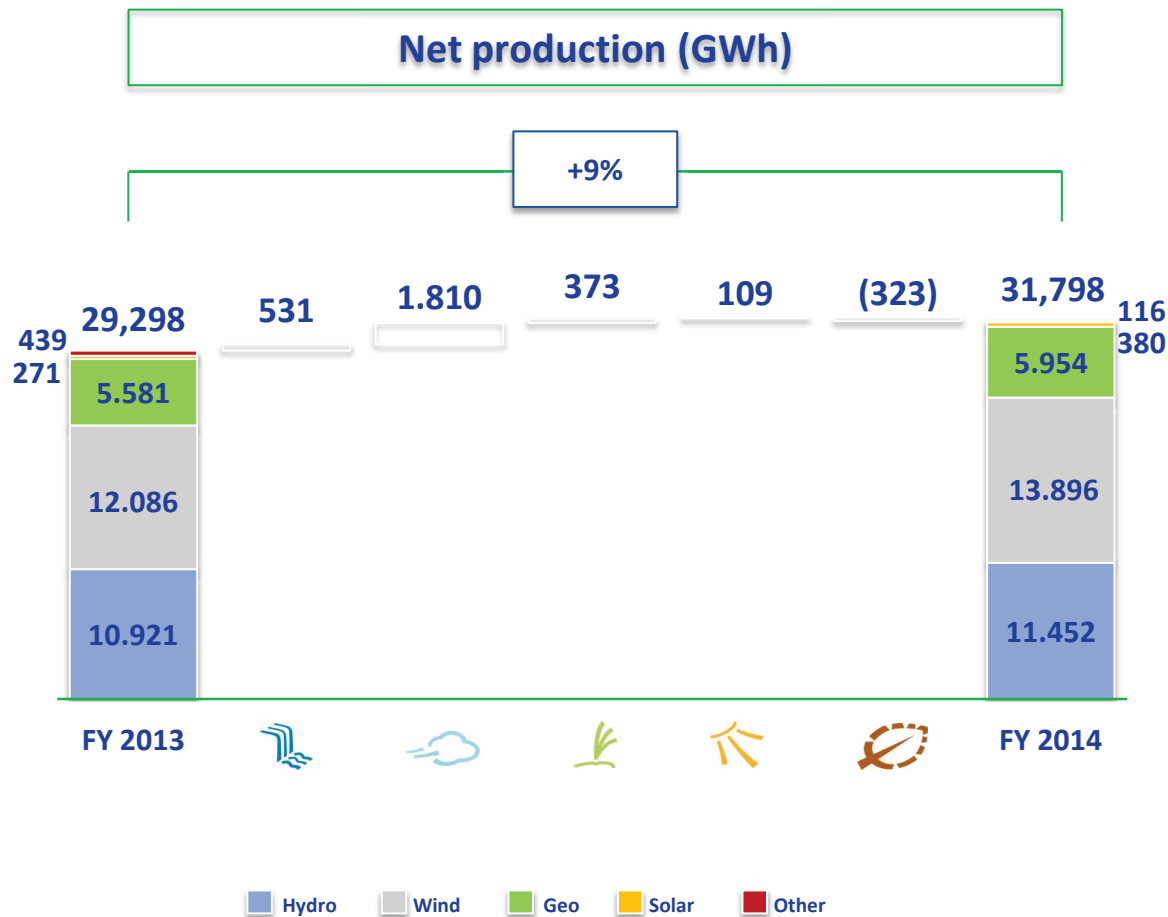
In execution = 2,0 GW



Geo Hydro Wind Biomass Solar



# Net production by technology (GWh)



**Load factor**

	FY 2013	FY 2014
Hydro	47%	50%
Wind	29%	30%
Geo	83%	85%
Solar	15%	16%
Enel Green Power	40%	40%

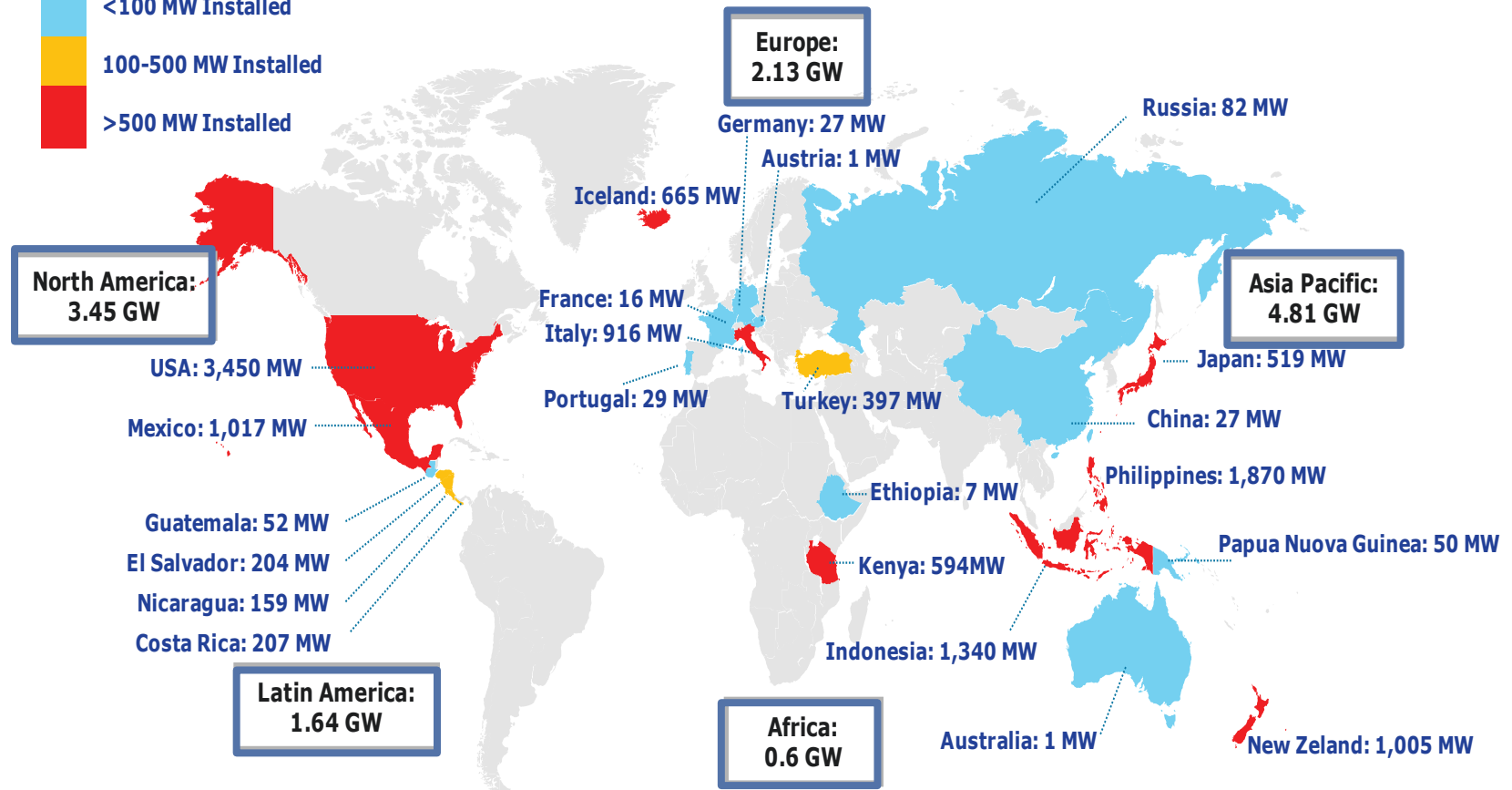
Geo Hydro Wind Solar Biomass

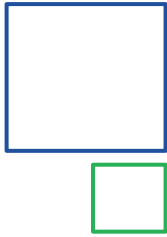
# The World Geothermal Electricity Status



2015 Geothermal Installed Capacity (MW)

**12,6 GW**

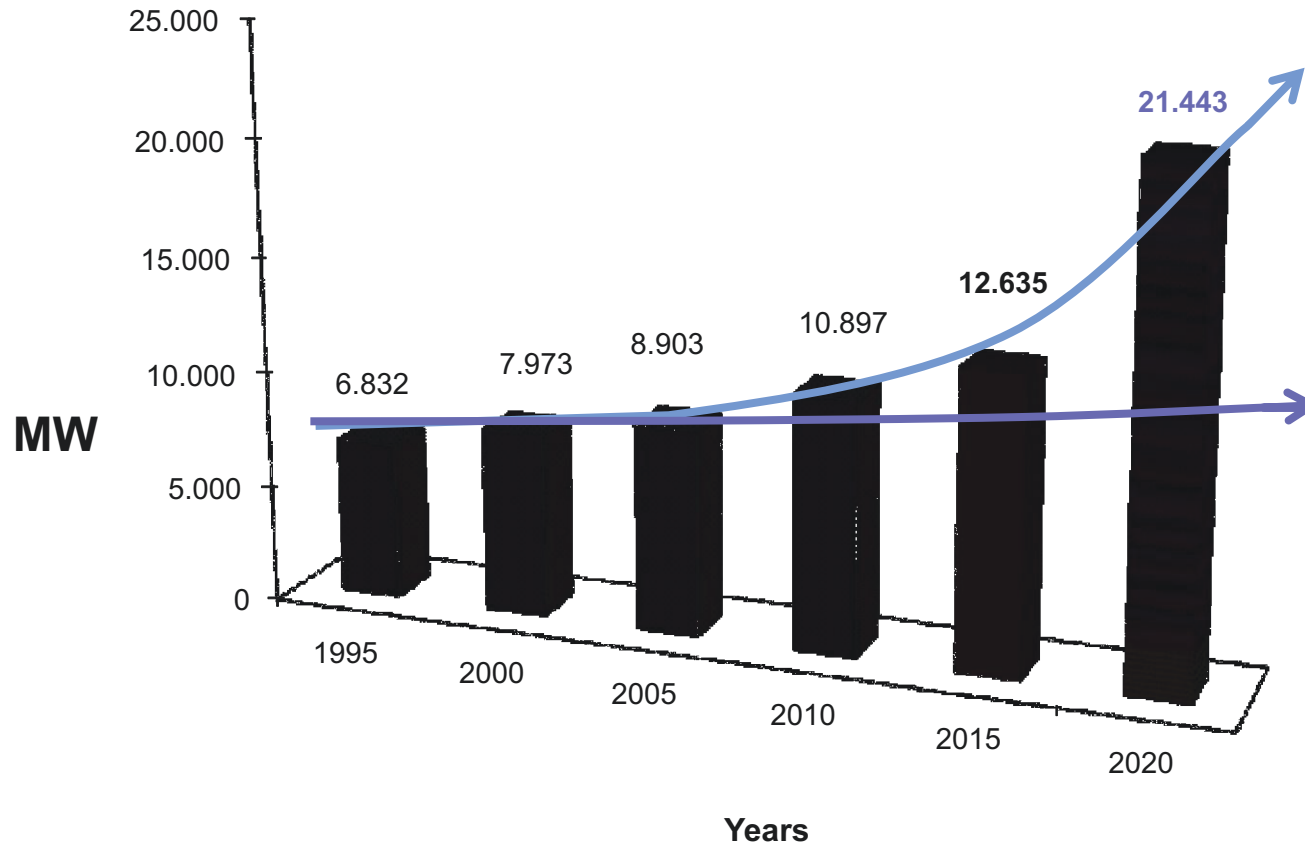


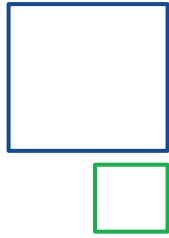


# The World Geothermal Electricity Trend



World Geothermal Electricity

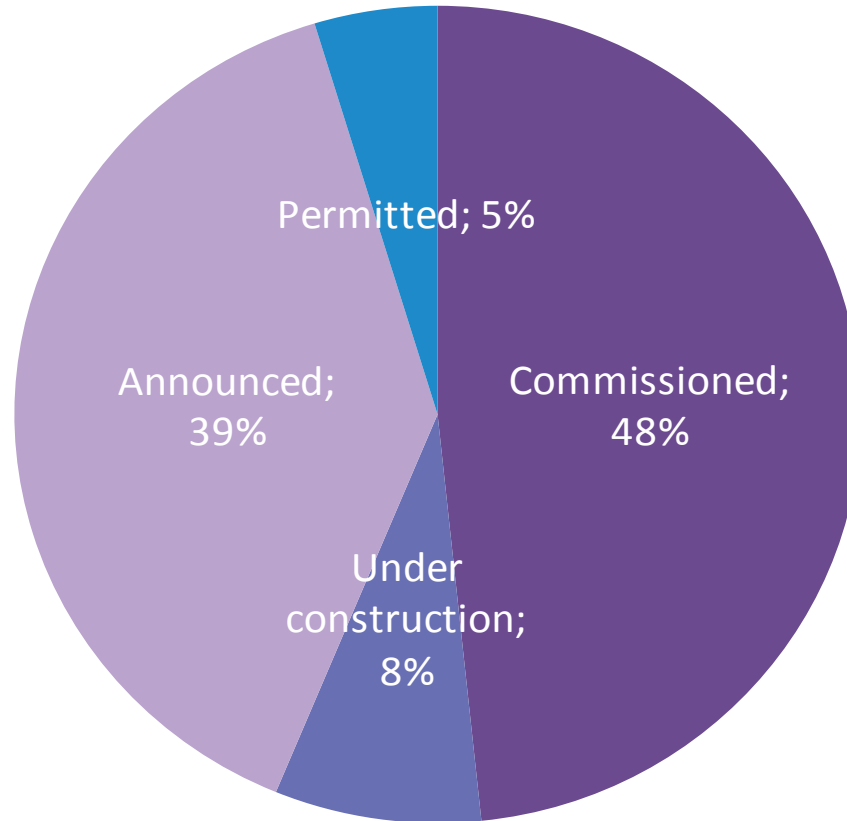


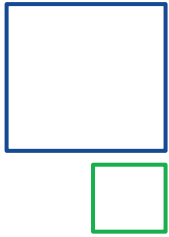


# The World Geothermal Electricity Trend








The global  
project pipeline  
totals  
**20 GW**  
across all  
development  
stages





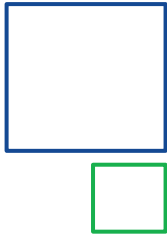
## Top 5 Countries: installed capacity > 1 GW



	COUNTRY	2010 MW	2010 GWh	2015 MW	2015 GWh
	USA	3,093	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	628	4,055	1,005	7,000





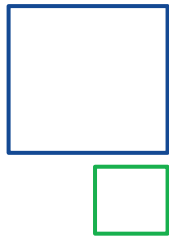


## Top 5 Countries: incremental capacity > 100 MW

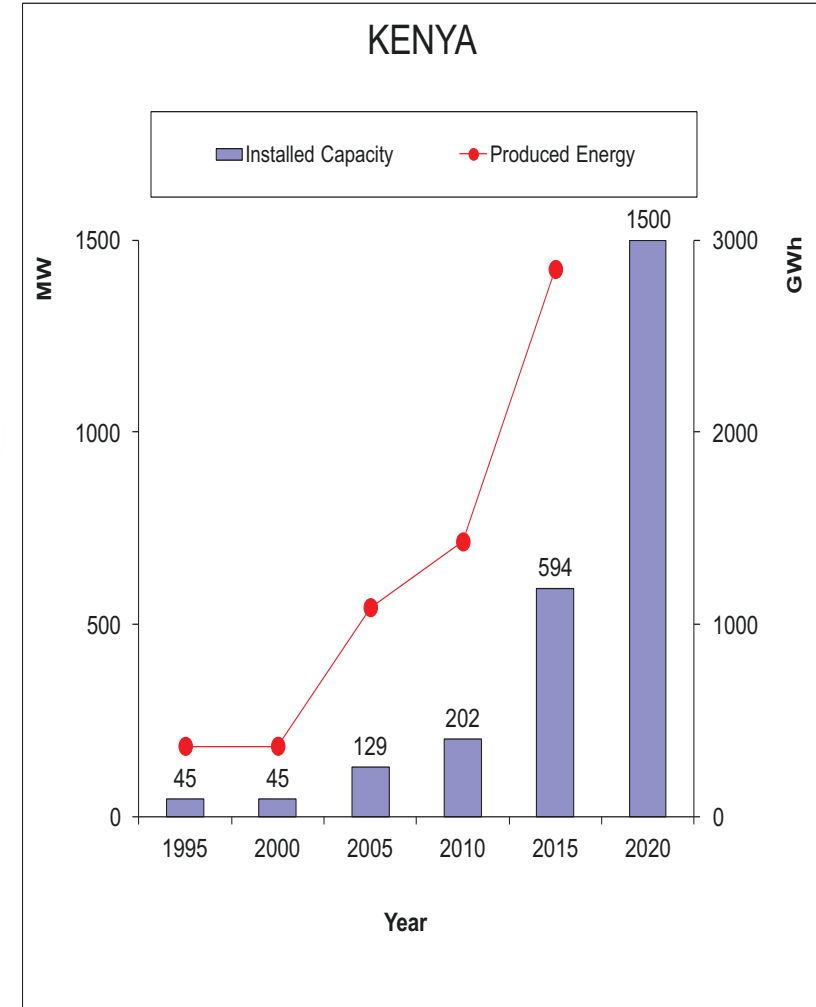


COUNTRY	2015 MW	2015 GWh	NEW MW	NEW GWh
KENYA	594	2,848	392	1.418
USA	3,450	16,600	352	
TURKEY	397	3,127	306	2.637
NEW ZEALAND	1,005	7,000	243	2.945
INDONESIA	1,340	9,600	143	





# Kenya

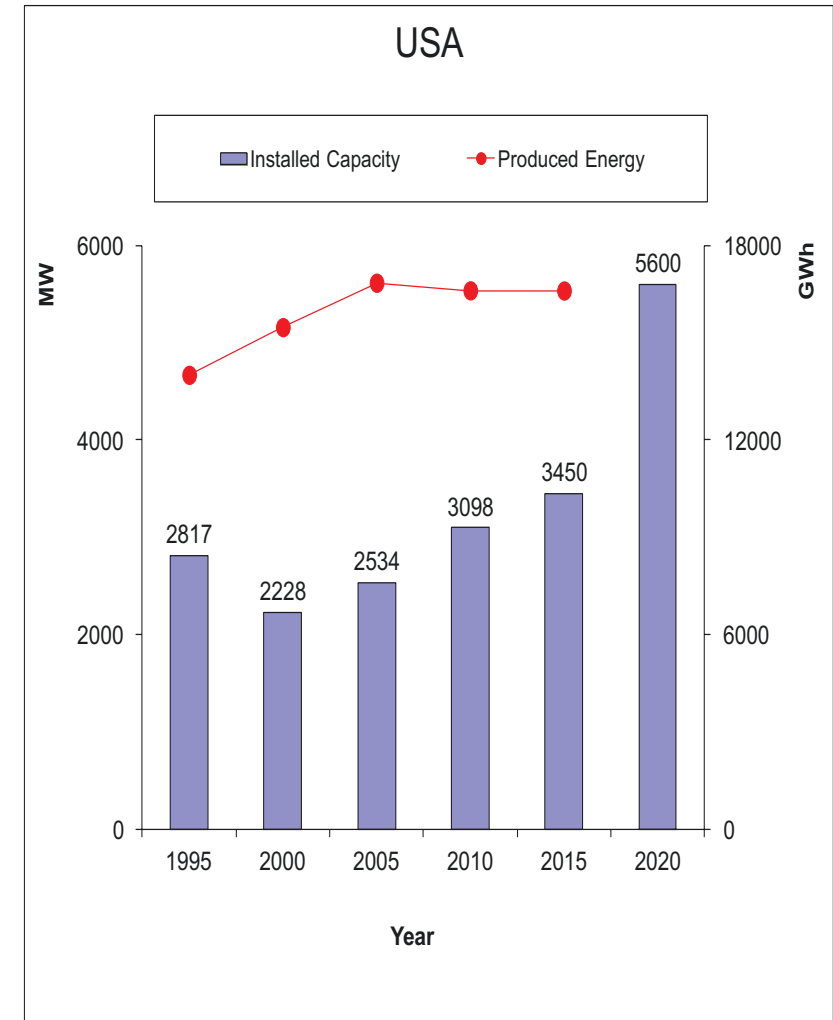




USA



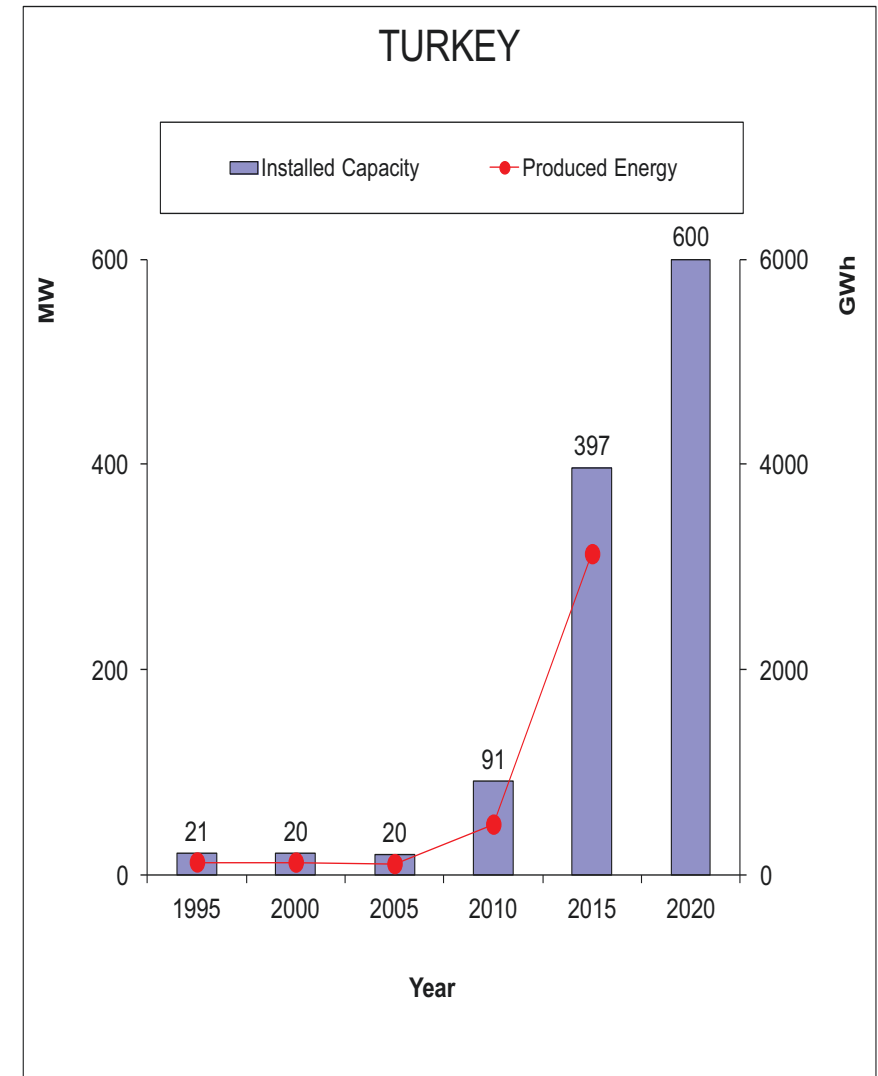
New Units in California, Hawaii, Nevada, New Mexico, Utah and Wyoming.

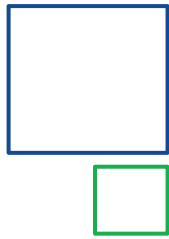


# Turkey



14 new Units for about 300 MW, located mainly in western Anatolia, on Menderes, Gediz and Simav valleys; a small unit in Çanakkale

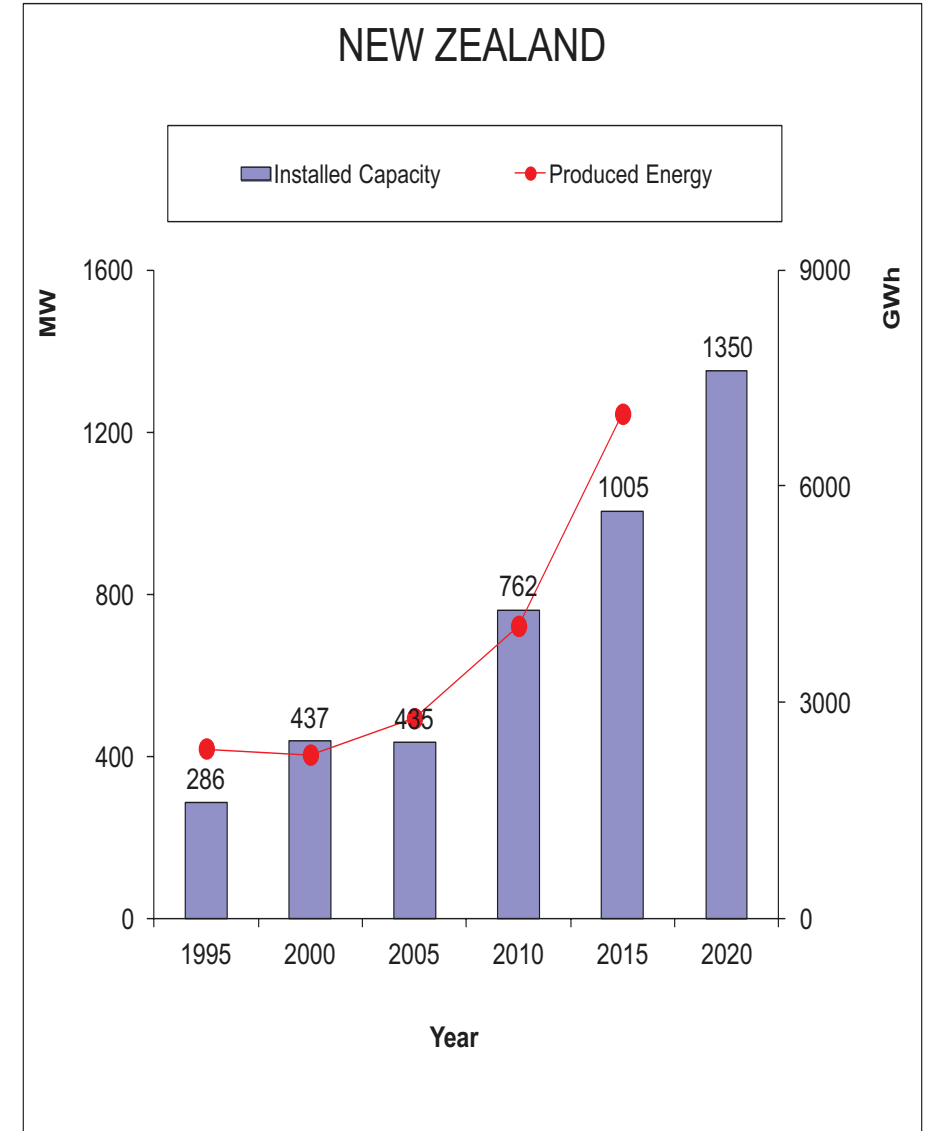




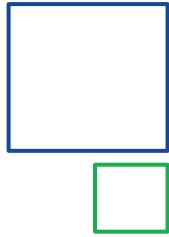
# New Zealand



About 250 new MW from 8 units at Ngatamariki, Tauhara and Wairakei. All the fields are in central part of North island, except Ngawha.







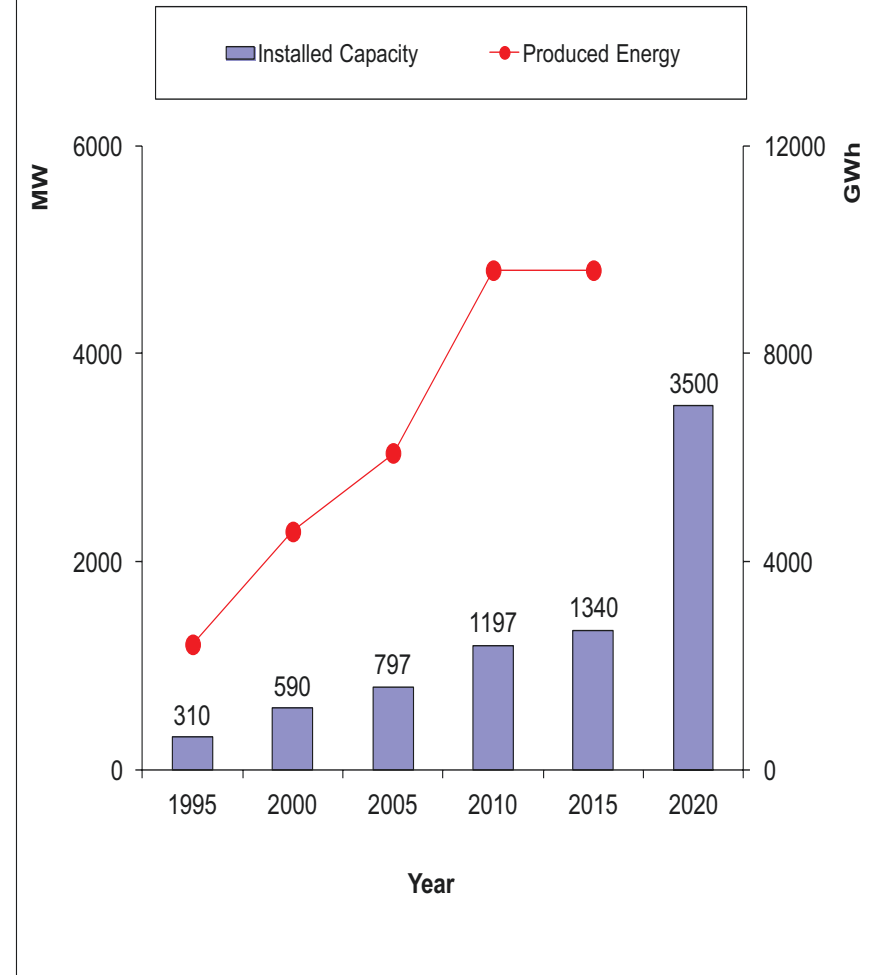
# Indonesia



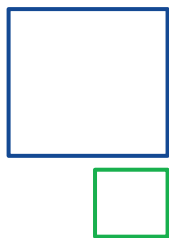
New plants have been commissioned at Flores – Ulumbu and Mataloko, Sulawesi – Lahendong and Sumatra - Ulu Belu.



## INDONESIA





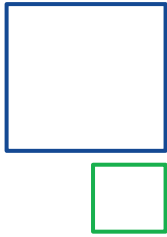


## Top 5 Countries: incremental capacity>30%



COUNTRY	2015 MW	2015 GWh	NEW MW	NEW GWh	% MW	% GWh
TURKEY	397	3,127	306	2.637	336%	539%
GERMANY	27	35	20		280%	
KENYA	594	2,848	392	1.418	194%	99%
NICARAGUA	159	492	72	182	82%	59%
NEW ZEALAND	1,005	7,000	243	2.945	32%	73%





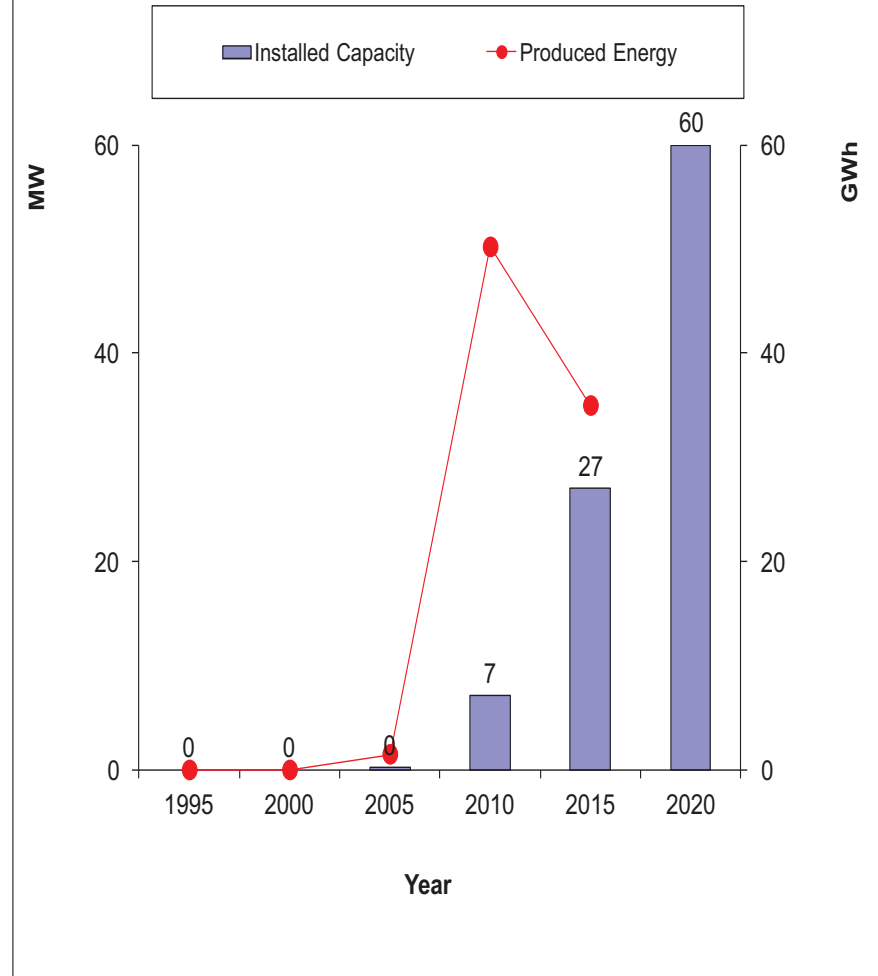
# Germany



Fuor new binary  
units about 5  
MW each and  
district heating  
at Sauerlach,  
Dürrnhaar,  
Kirchstockach  
and Insheim



## GERMANY



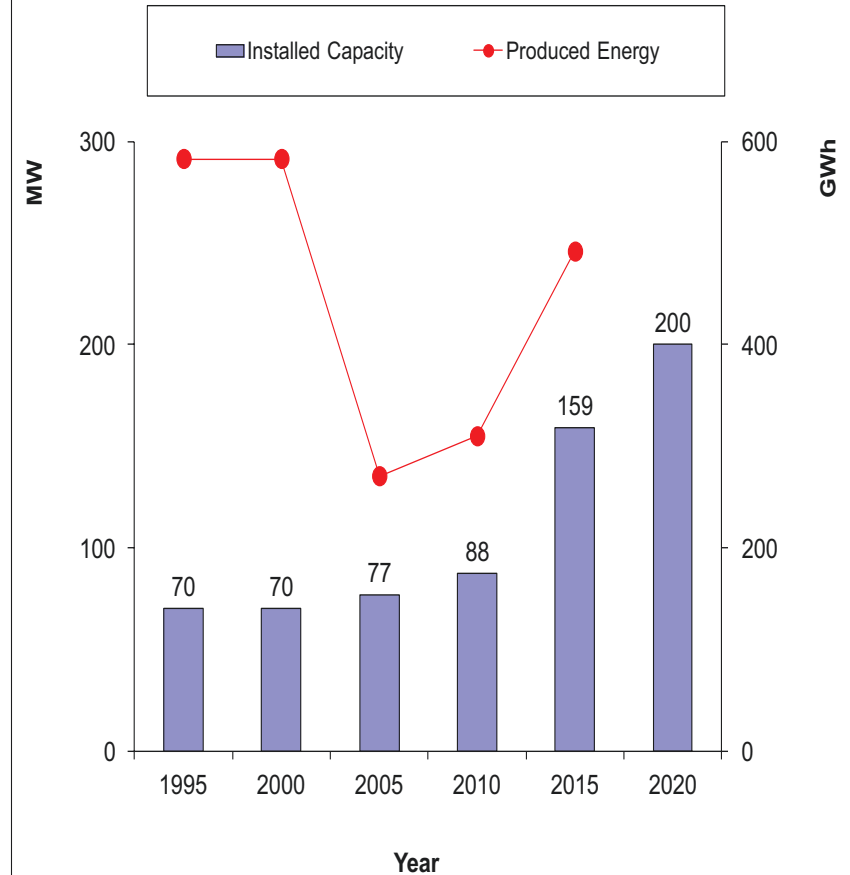
# Nicaragua



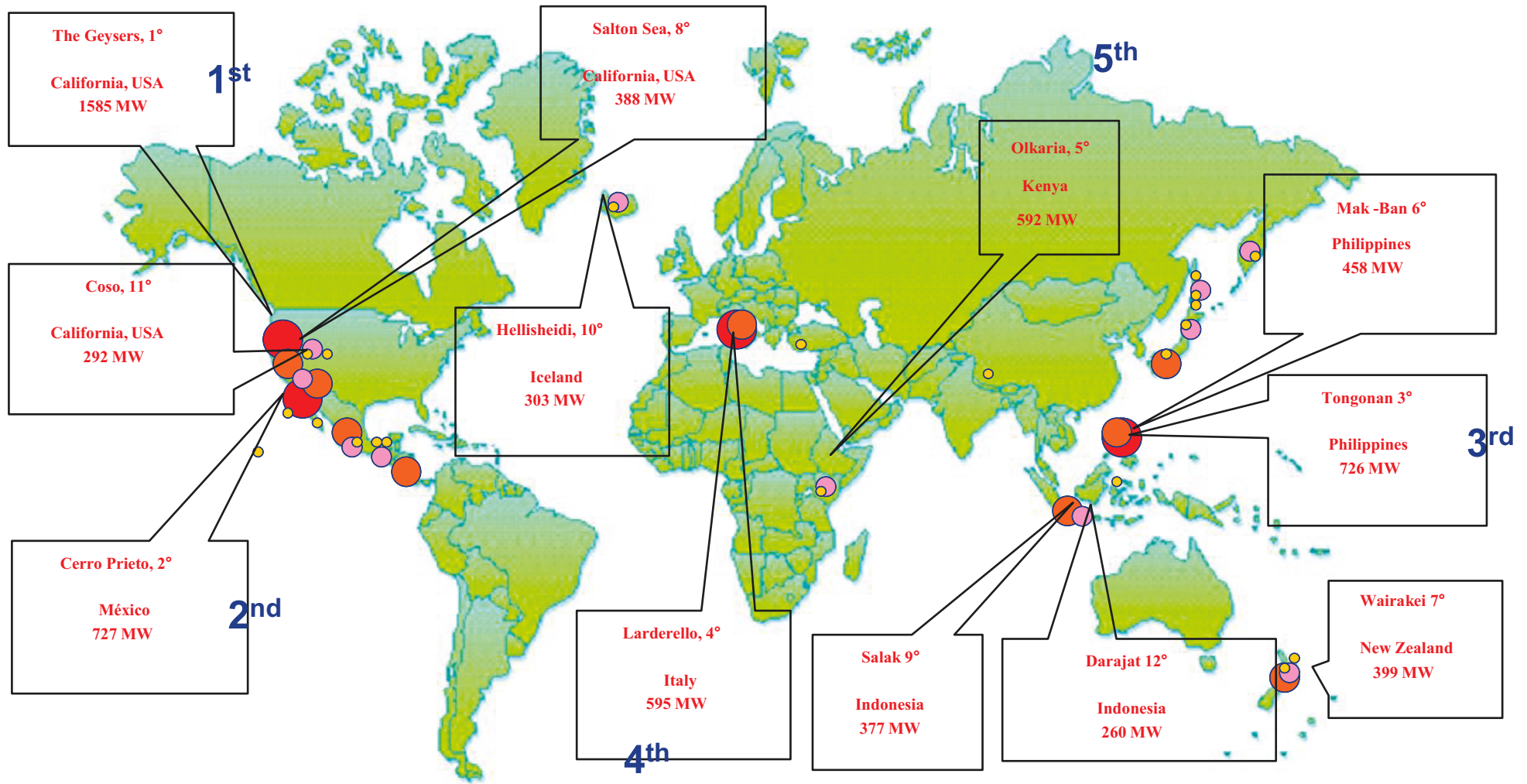
New units at  
San Jacinto-  
Tizate 2x26  
MW Fuji  
single flash

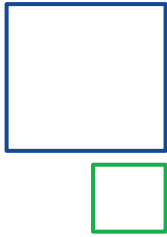


## NICARAGUA



# 2015 Top Dozen of Geothermal Fields



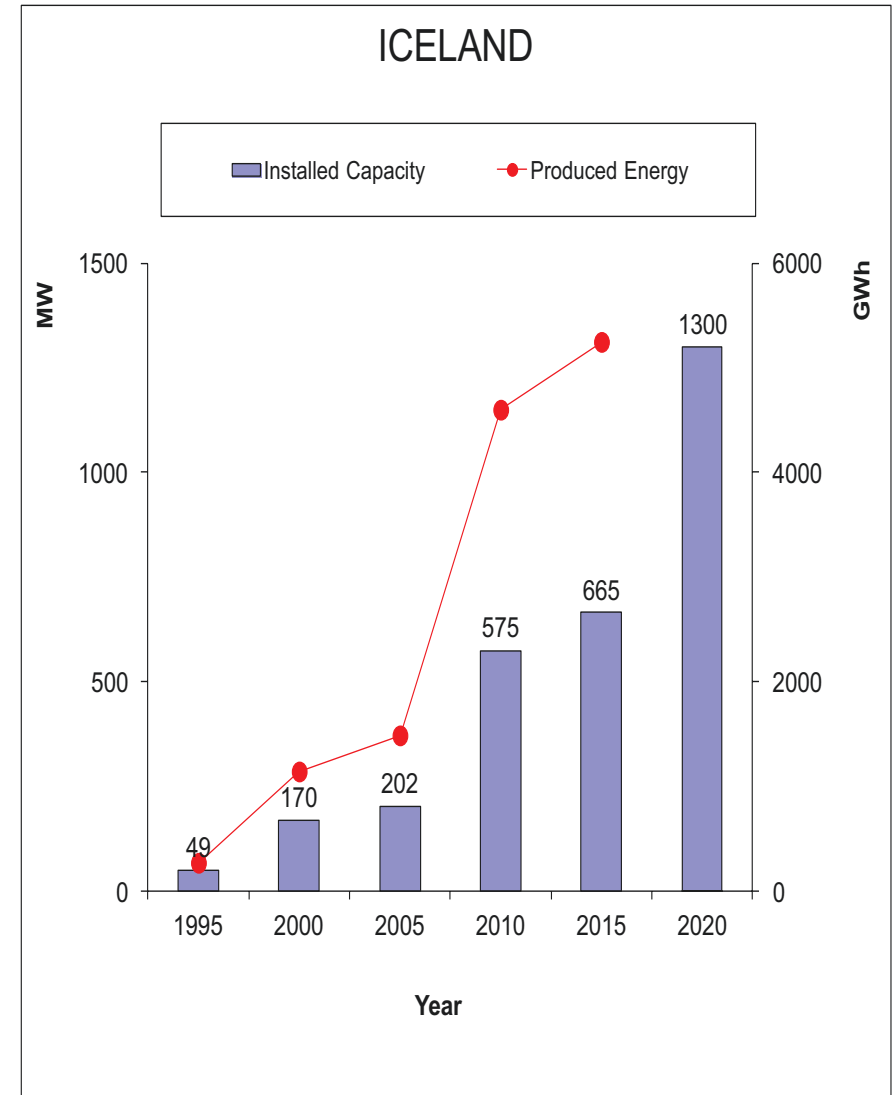


# Iceland

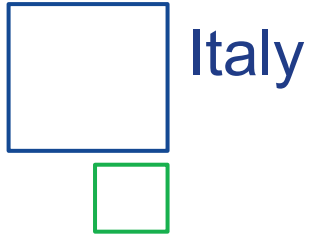


Base 504778 (546541) 10-81

New units in Hellisheidi 2x45 MW  
single flash Mitsubishi;  
Focus on heating and cascade applications.







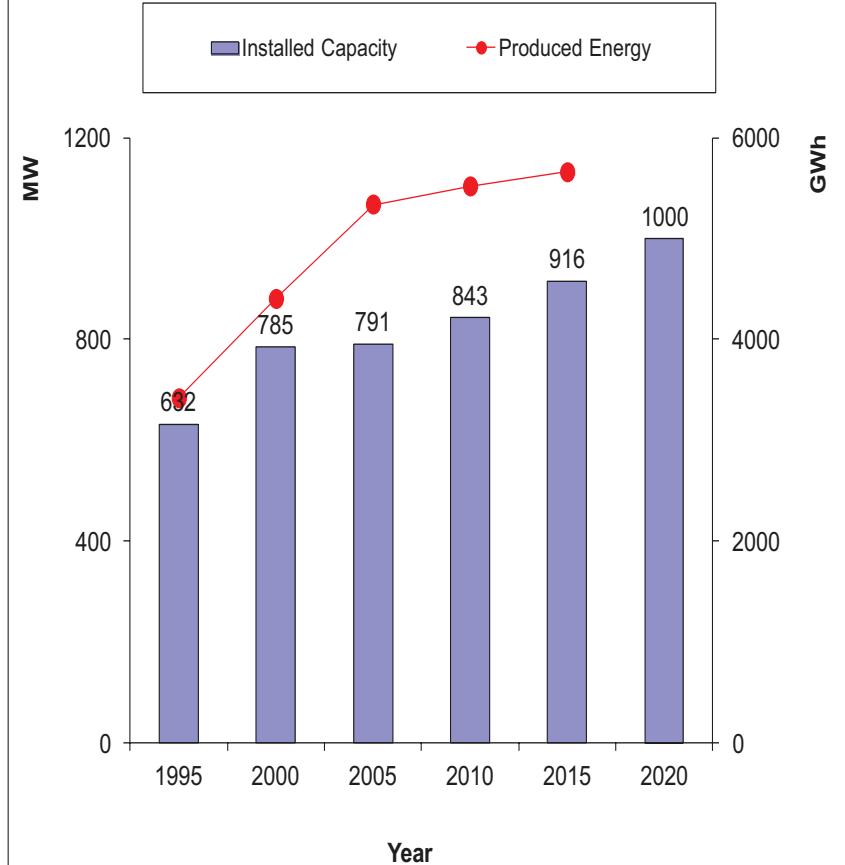
Italy



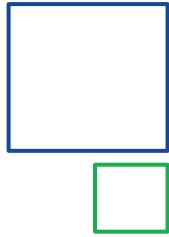
A new unit in Bagnore (40 MW); the first Italian binary unit; the first hybrid project geothermal-biomasses.



## ITALY

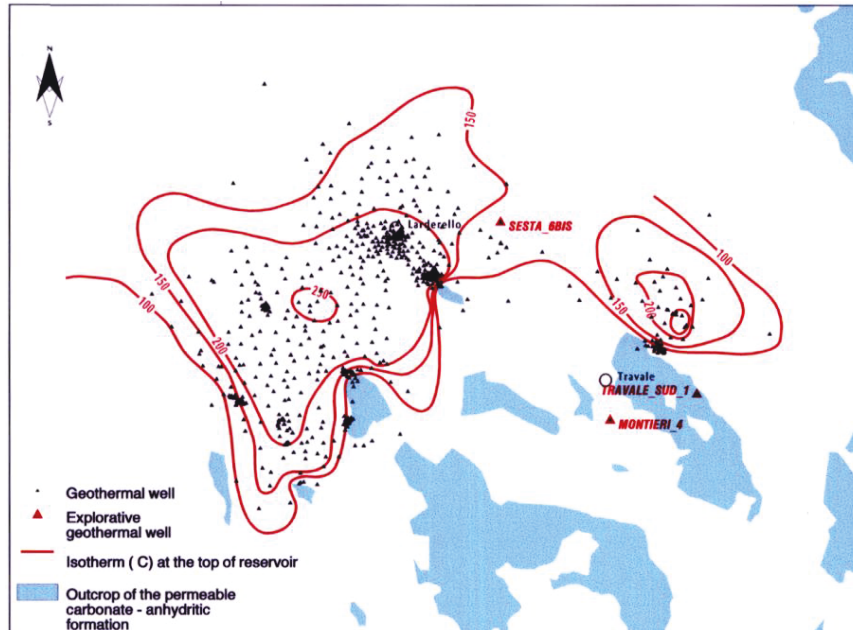




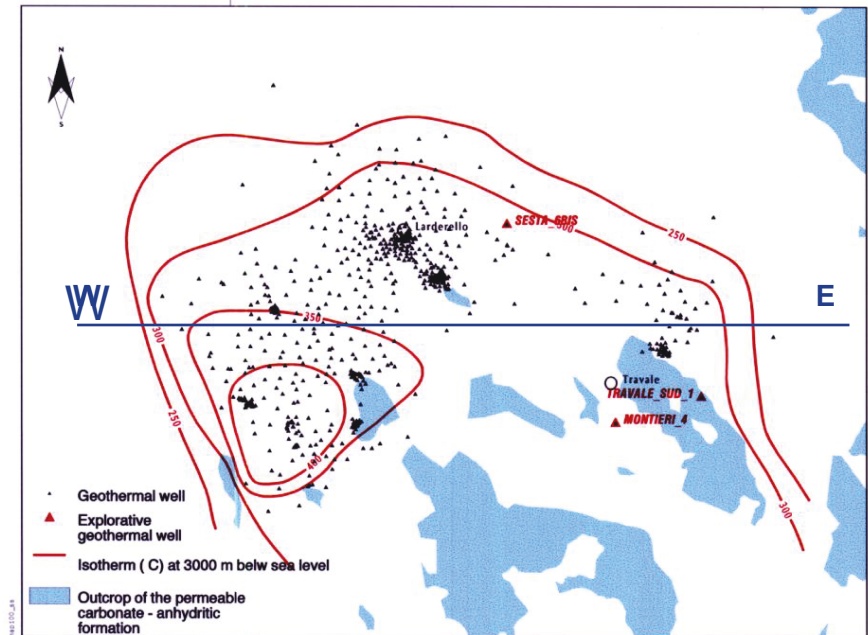


# Production sustainability

## Deep exploration



Temperature at the top of the shallow Carbonate Reservoir

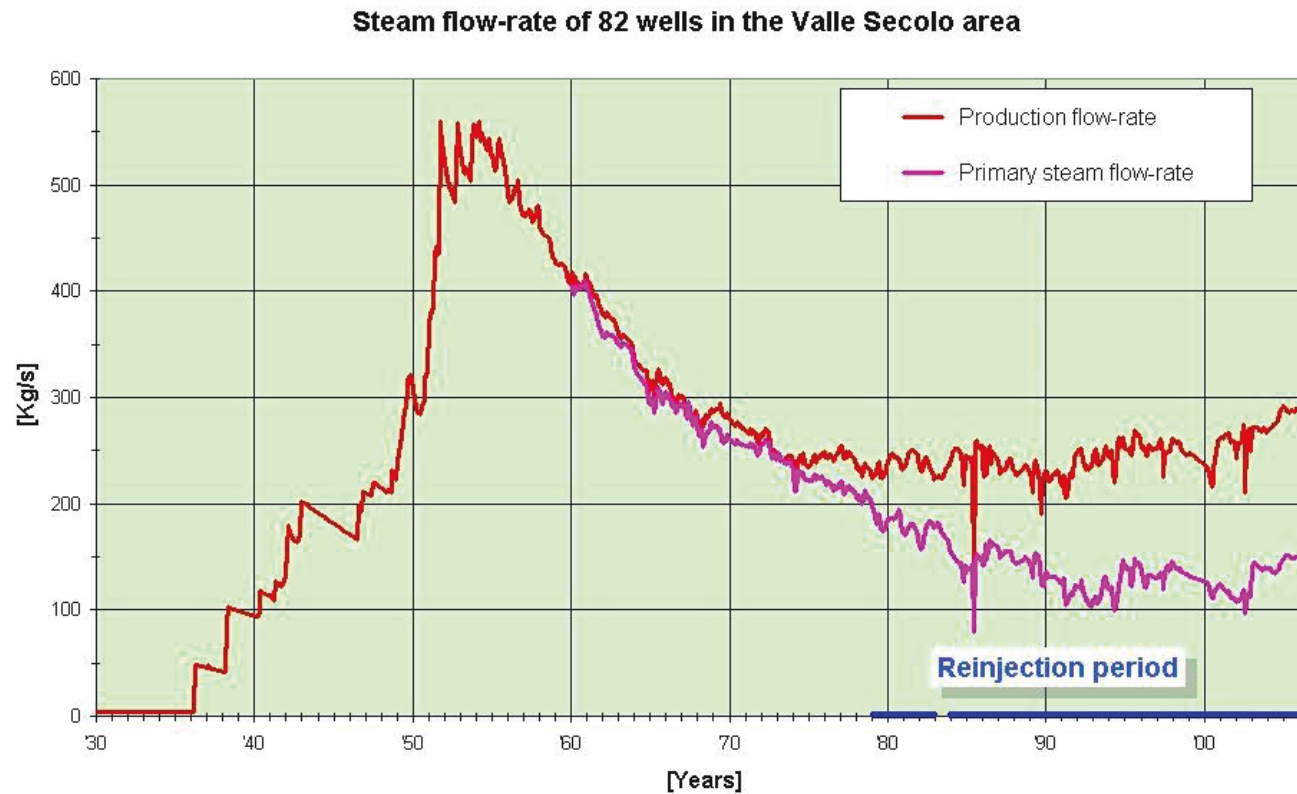


Temperature at 3000 m b.g.l.

A unique system at great depth

# Production sustainability

## Reinjection in the Valle Secolo area



Reinjection represents by now an “exploitation strategy”



# Power plants



- External color blends with landscape
- Architectural elements





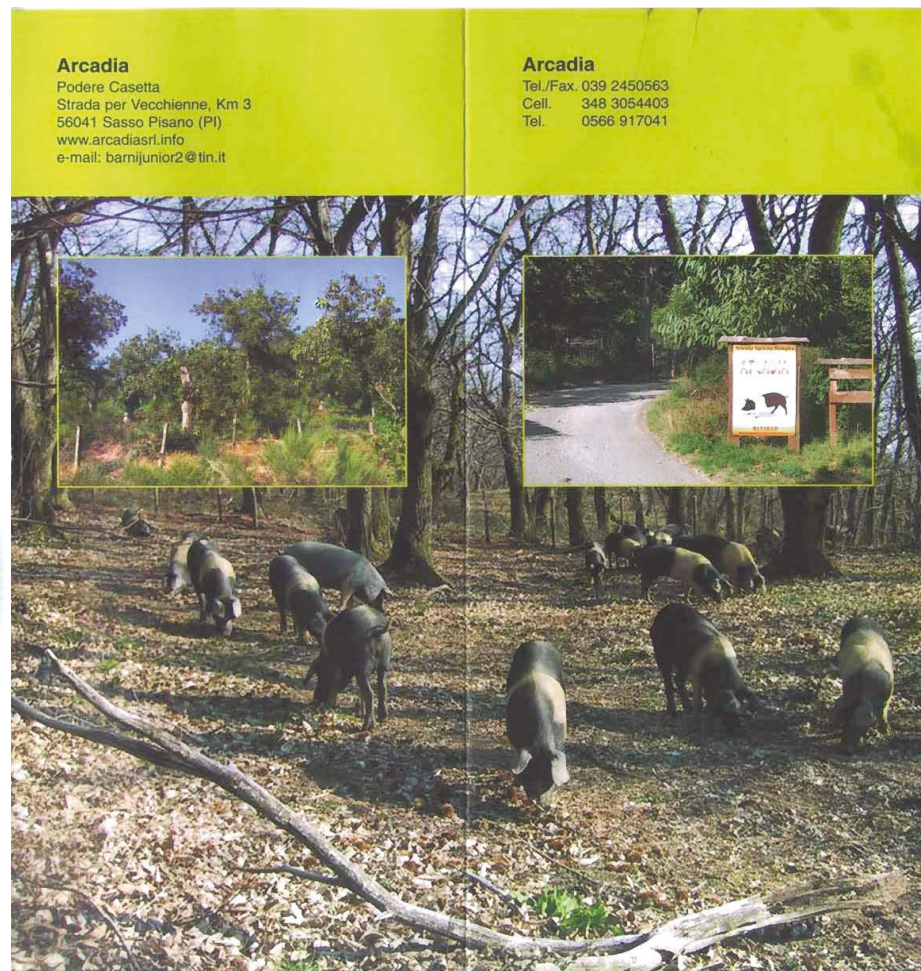
# Direct use promotion



37% of the heat is delivered to  
greenhouses



## Direct use promotion



1% of the total heat is used in cheese and salami production activities

# Direct use

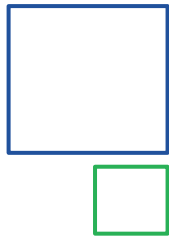
## District heating in Tuscany



Forniture Calore	uso	Contratto del	Potenza nominale Gcal/h	utenze servite		Consumo Gcal/anno	risparmio annuo		CO <sub>2</sub> evitata t
				n°	m <sup>3</sup>		TEP	CH <sub>4</sub> [m <sup>3</sup> ]	
<b>TOT. COMUNE CASTELNUOVO V.C.</b>				<b>1097</b>	<b>291.681</b>	<b>26.913</b>	<b>2.691</b>	<b>3.588.458</b>	<b>8.343</b>
CASTELNUOVO V.C.(capoluogo)	TR	25/01/1985	6,24	827	223.000	20.942	2.094	2.792.220	6.492
SASSO PISANO	TR	25/10/1993	2,00	173	42.500	4.657	466	620.891	1.444
SEI - TR villaggi aziendali	TR	2001/2002		93	23.031	1.231	123	164.119	382
ALTRE UTENZE ISOLATE	TR		0,11	4	3.150	84	8	11.229	26
STOLFI (pod. Caspeci)	TR	13/12/1993	0,01	1	300	22	2	2.965	7
CIOMPI (pod. S. Francesco)	TR	23/12/1998	0,01	1	350	20	2	2.667	6
TADDEI (Pian della Colombaia)	TR	12/11/2001	0,03	1	900	29	3	3.827	9
FRANCHI (pod. Le Franate)	TR	01/10/2005	0,06	1	1.600	13	1	1.769	4
<b>TOT. COMUNE POMARANCE</b>				<b>2020</b>	<b>584.444</b>	<b>39.876</b>	<b>3.988</b>	<b>5.316.792</b>	<b>12.362</b>
POM. (Ina casa)	TR	09/02/2001	1	78	19.865	1.070	107	142.702	332
POM. (Montecerboli)	TR		3	400	108.232	5.691	569	758.818	1.764
POM. (Serrazzano)	TR		2	223	54.321	2.827	283	376.885	876
POM. (Lustignano)	TR		1	94	20.056	901	90	120.151	279
POM. (San Dalmazio)	TR		1	96	22.763	6.483	648	864.344	2.010
POM. (Capoluogo)	TR		10	843	273.323	19.032	1.903	2.537.640	5.900
SEI - TR villaggi aziendali	TR	2001/2002	3	283	83.784	3.693	369	492.358	1.145
ALTRE UTENZE ISOLATE	TR		0	3	2.100	179	18	23.893	56
SALVADORI (Mulino La Perla)	TR	20/03/1998	0	1	600	40	4	5.333	12
BERTI (pod. Le Mulina)	TR	31/12/1993	0	1	300	24	2	3.160	7
CARAI (pod. S. Marco)	TR	19/12/2002	0,04	1	1.200	116	12	15.400	36
<b>TOT. COMUNE MONTEROTONDO M.mo</b>	<b>TR</b>	<b>25/10/1993</b>	<b>2</b>	<b>399</b>	<b>102.524</b>	<b>8.917</b>	<b>892</b>	<b>1.188.967</b>	<b>2.764</b>
COMUNE MONTEROTONDO M.mo	TR	25/10/1993	2,00	350	92.000	8.246	825	1.099.447	2.556
SEI - TR villaggi aziendali	TR	2001/2002		49	10.524	671	67	89.520	208
<b>TOT. COMUNE SANTA FIORA *</b>	<b>TR</b>	<b>21/12/1999</b>	<b>13</b>	<b>400</b>	<b>94.118</b>	<b>6.353</b>	<b>635</b>	<b>847.059</b>	<b>1.969</b>
<b>totali riscaldamento Toscana</b>				<b>3.916</b>	<b>1.072.766</b>	<b>82.060</b>	<b>8.206</b>	<b>10.941.276</b>	<b>25.438</b>

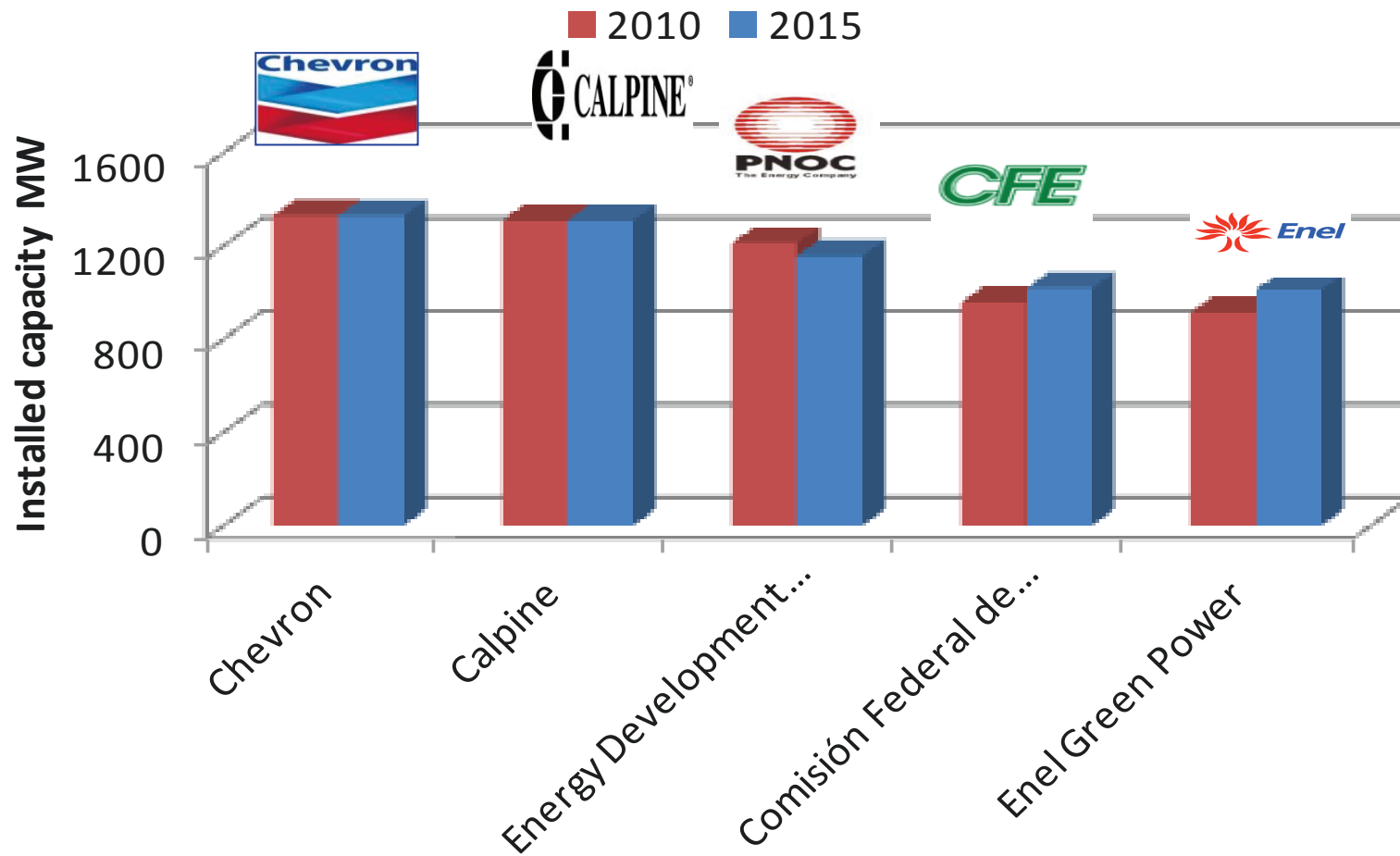
Total production of heat 273 Tcal ➔ 85000 avoided ton CO2





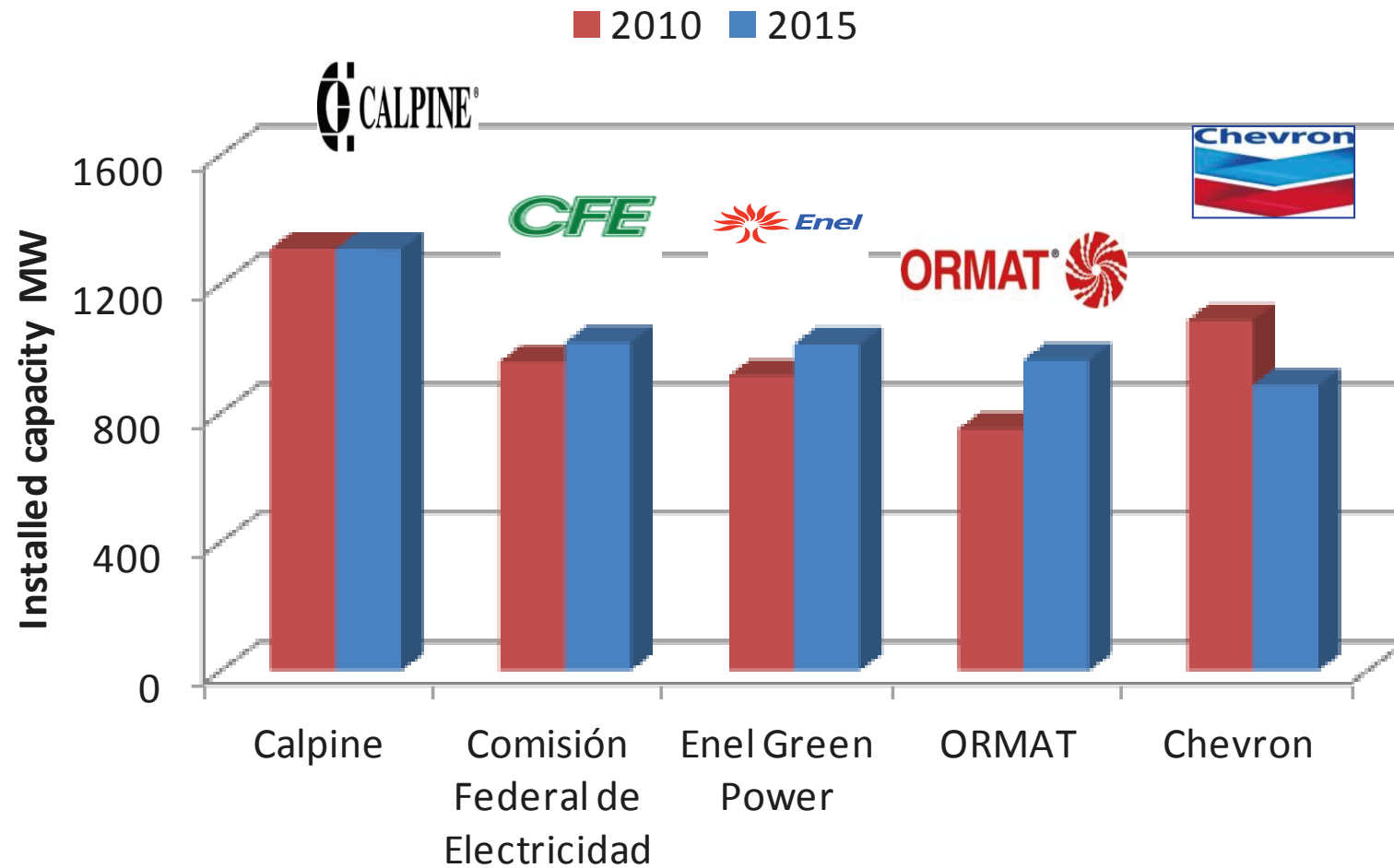
# 2015 Geothermal World

## Geothermal Field operator

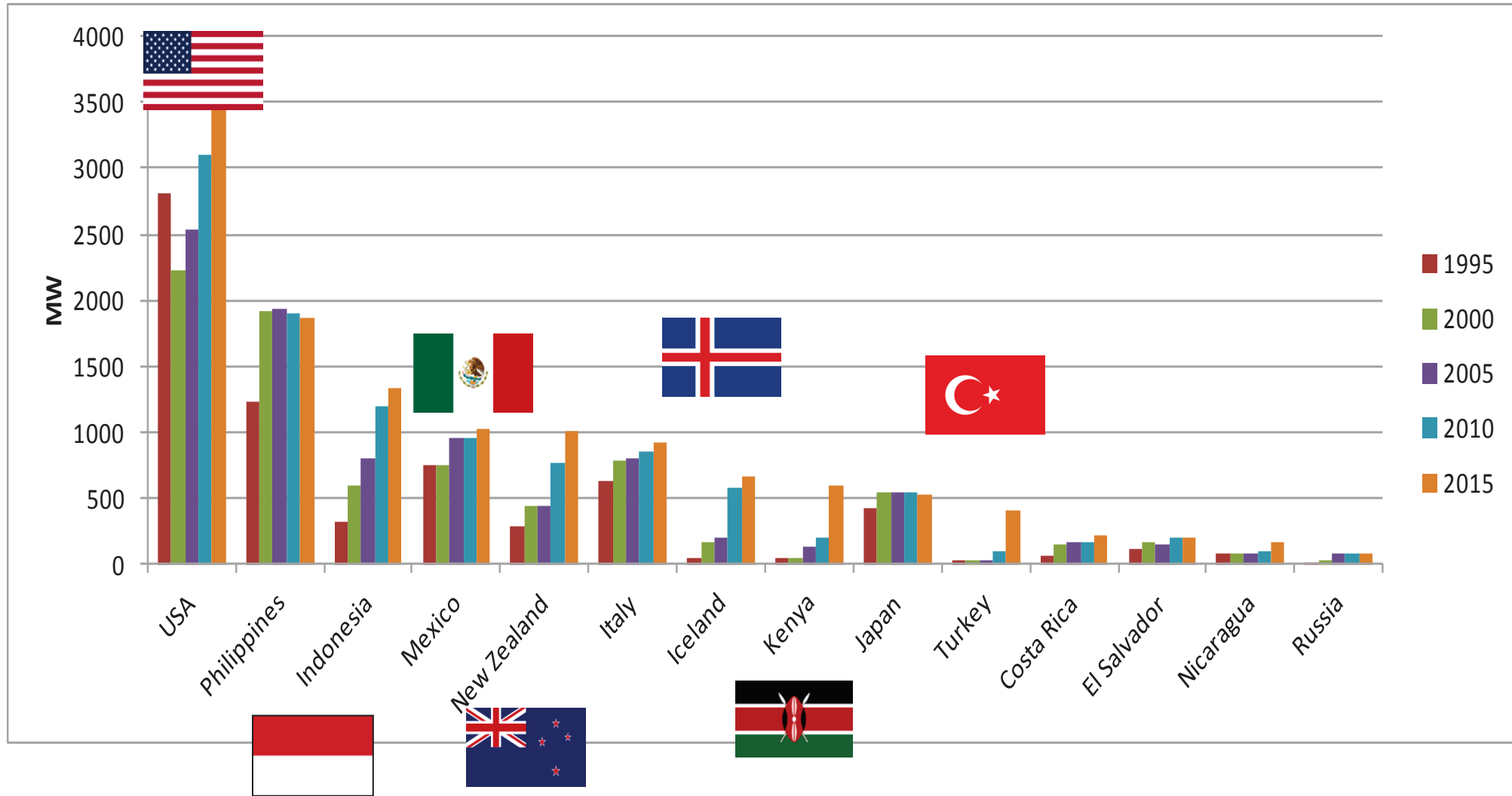


# 2015 Geothermal World

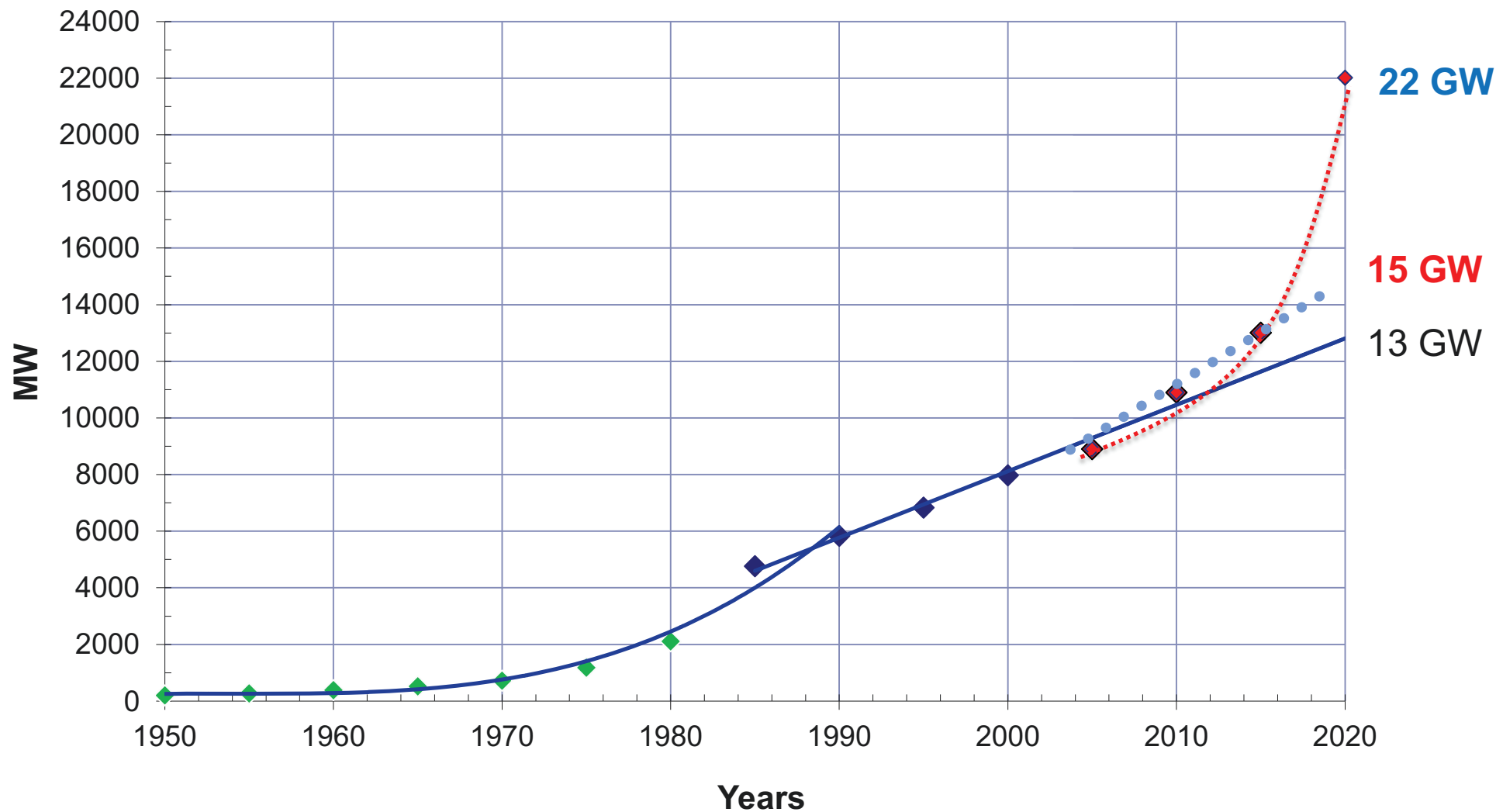
## Geothermal Plant operator

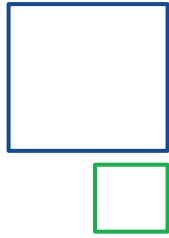


# 2015 Geothermal World: country trends



Looking to the future  
Medium and long term





## Direct uses

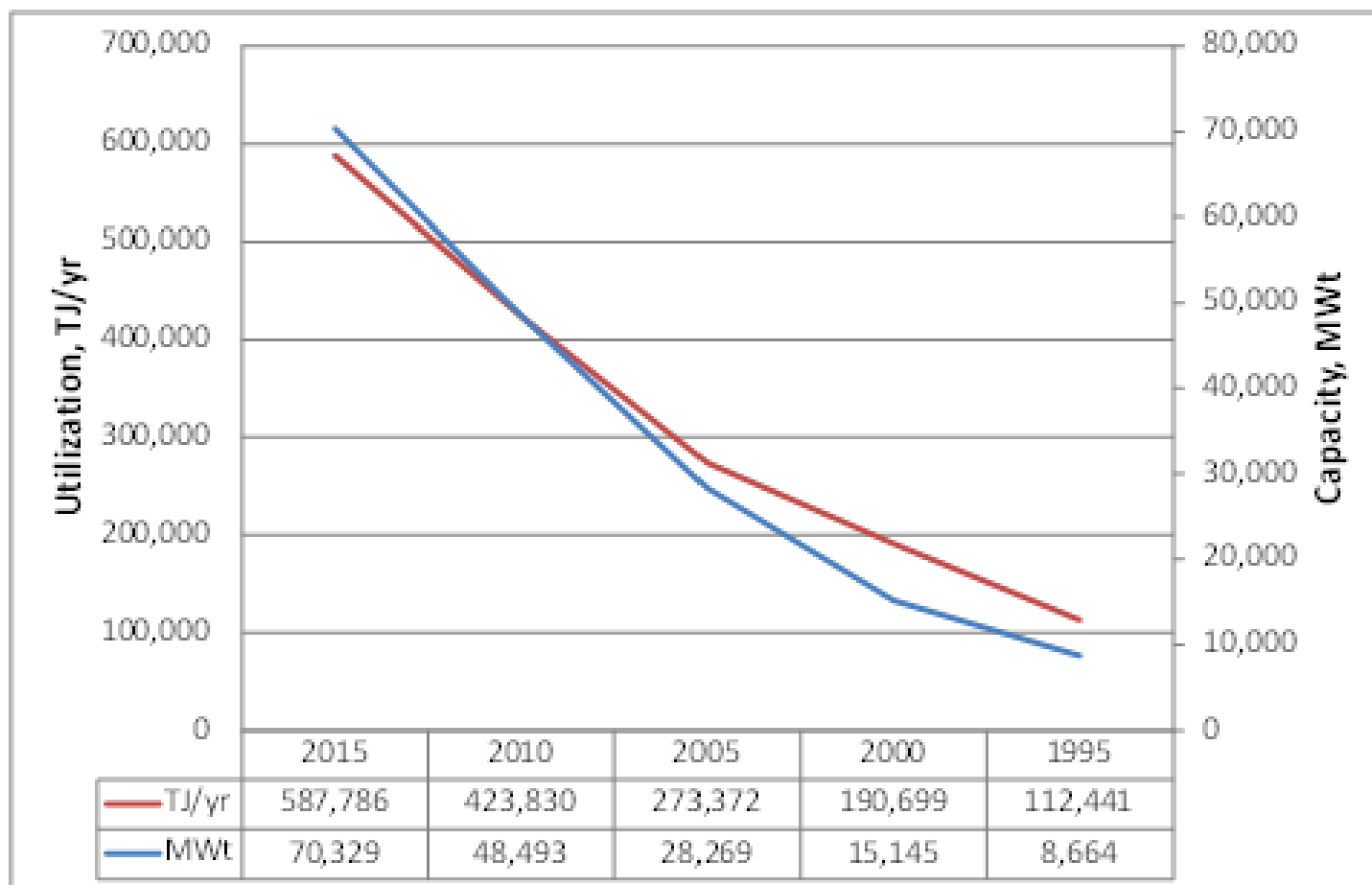


Direct utilization of geothermal energy in a total of **82 countries** is an increase from the 78 in 2010, 72 in 2005, 58 in 2000, and 28 in 1995.

The installed thermal power for direct utilization at the end of 2014 is 70,329 MWt, almost a 45% increase over the 2010 data.

Energy savings amounted to 350 million barrels (52.5 million tonnes) of equivalent oil annually, preventing 46 million tonnes of carbon and 148 million tonnes of CO<sub>2</sub> being released to the atmosphere, this includes savings for geothermal heat pumps in the cooling mode (compared to using fuel oil to generate electricity).

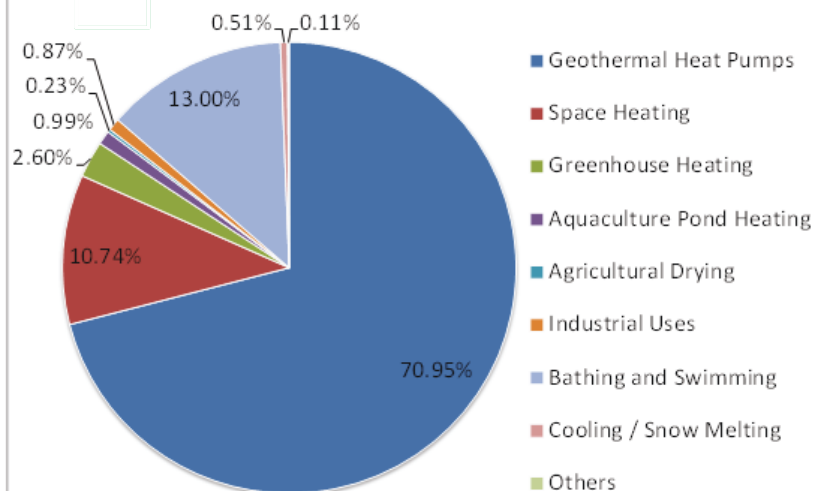
## Direct uses: history



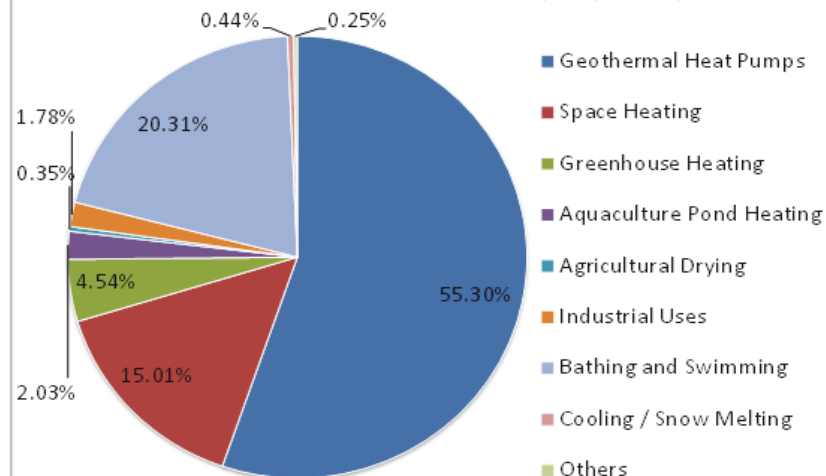
# Direct uses: applications



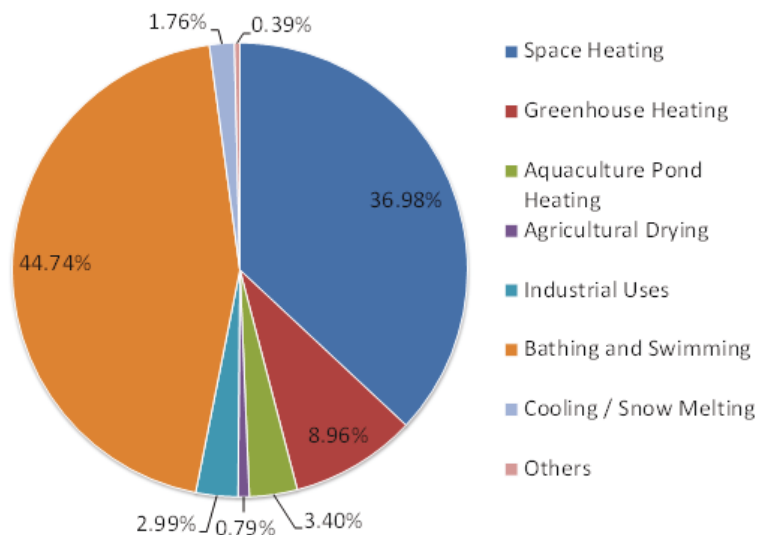
World-Wide Capacity (with heat pumps), MWt



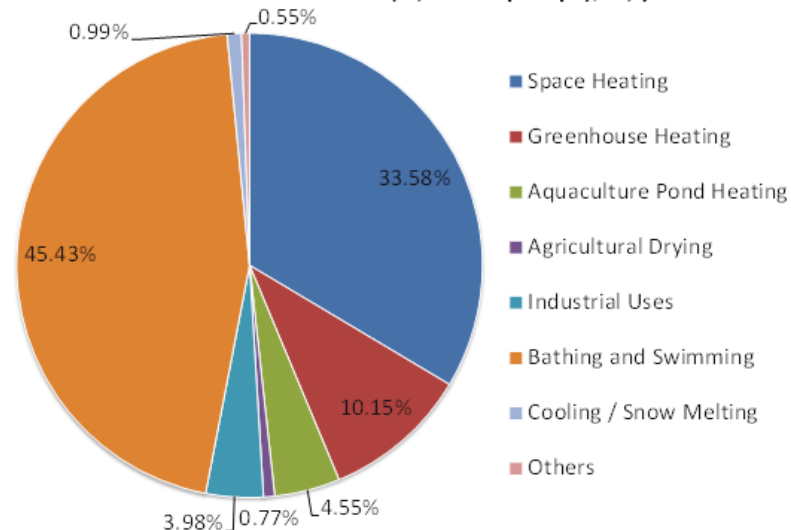
World-Wide Utilization (with heat pumps), TJ/yr



World-Wide Capacity (w/o heat pumps), MWt

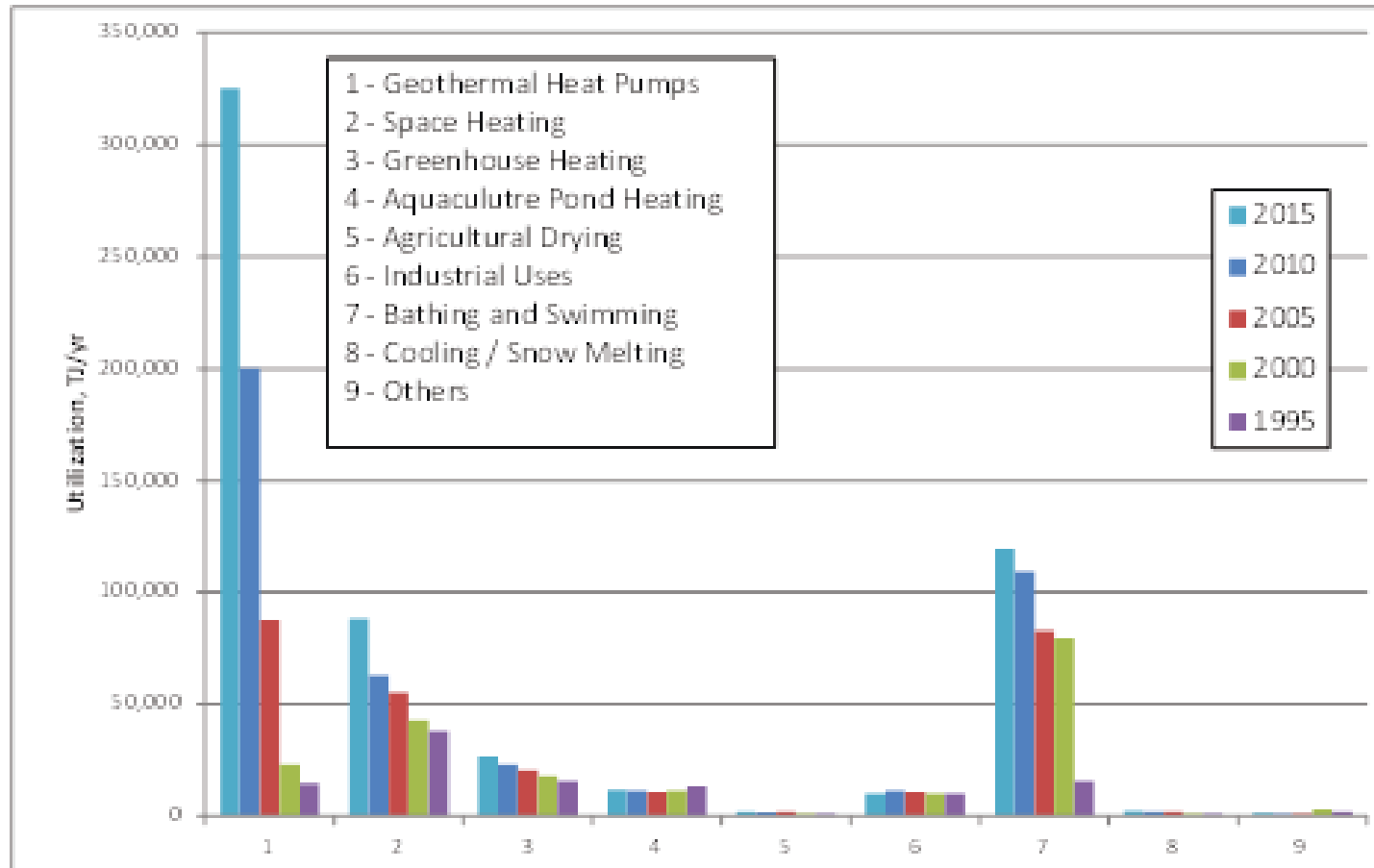


World-Wide Utilization (w/o heat pumps), TJ/yr



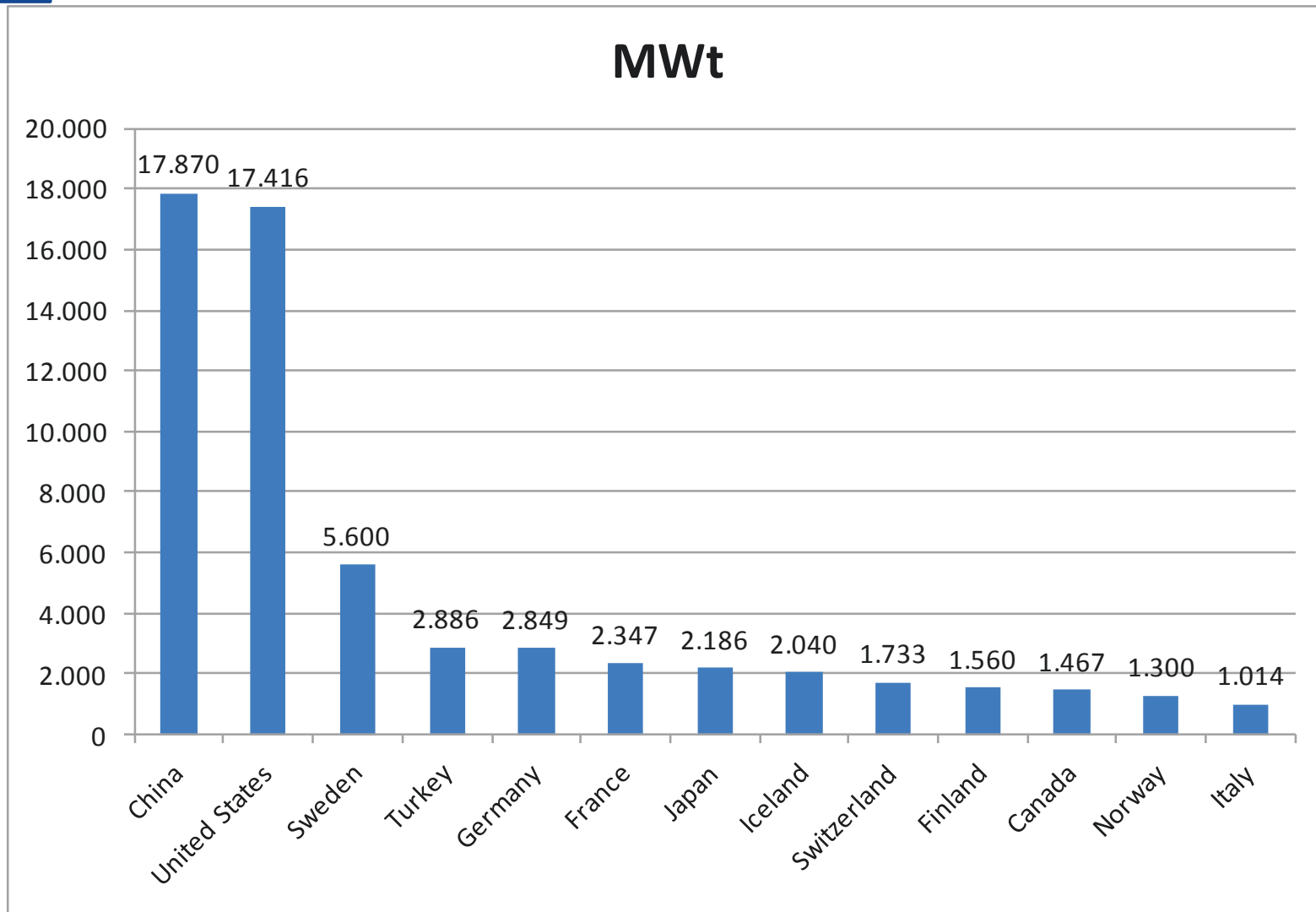


## Direct uses





## Direct uses: country overview





## Direct uses: Top Players



**Iceland**

90% of building heated



**Japan**

2000 onsens, 5000 public baths, 1500 hotels serving 15 million guests/year



**Sweden**

20% of building heated using geothermal heat pumps



**Switzerland**

90,000 geothermal heat pumps installed (~3 units/km<sup>2</sup>)



**Tunisia**

244 ha of greenhouses heated



**Turkey**

90,000 apartment residences heated in 16 cities – approaching 30% of the total units



**USA**

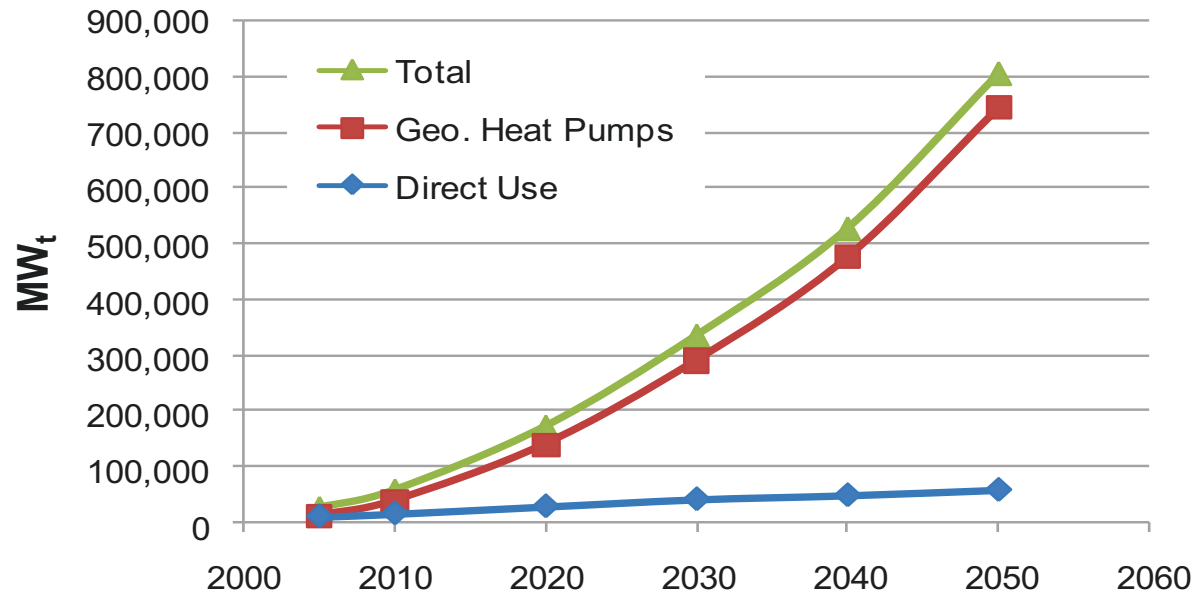
1.4 million geothermal heat pumps (7.0% annual growth)



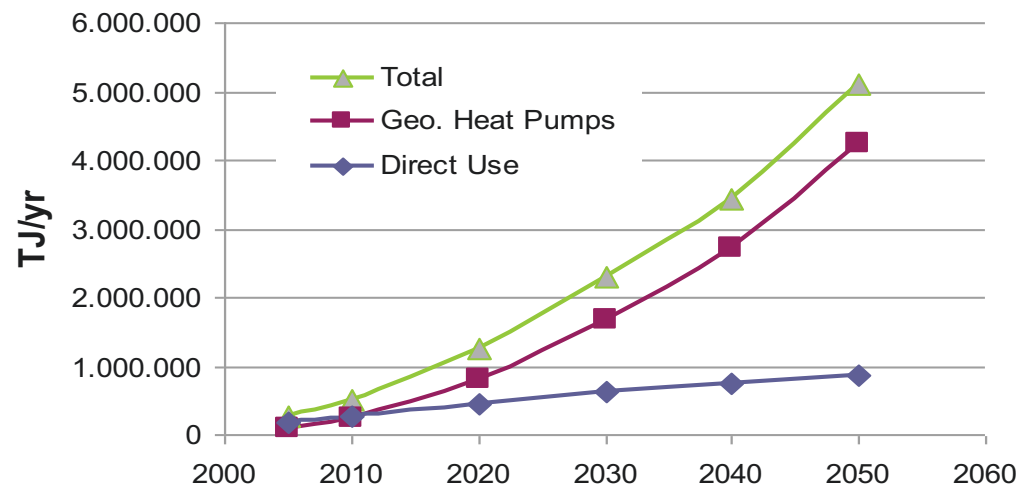
**CHINA**

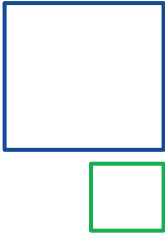
World leader in direct uses

# Direct uses: forecasting



Long-Term Forecasting  
of direct utilization energy  
and installed capacity





THANKS FOR YOUR KIND ATTENTION