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Employment study: solutions on lack of skilled workers in the geothermalsector & results of the questionnaires

EXECUTIVE SUMMARY

Geothermal energy develops a perspective on the creation of several new jobs. Because of the many different disciplines that are required in the industry, there are jobs provided for a wide range of different types of specialities, with different level of skills, experience and education, concerning low skilled, medium skilled (technical, skilled crafts, supervisory) and highly skilled (professional and managerial) occupations.

Objective of this study is to record the status of the employment of the geothermal electricity sector: estimate the jobs created in the sector and identify the skill gaps and workforce shortages that exist or that may occur.

In order to estimate the new jobs that will be created in the geothermal electricity sector during the next 20 years, we use the coefficients of 3,9 person*years/ MW for manufacturing jobs, 6,8 person*years/ MW for construction jobs and 0,36 jobs/ MW for O&M. A realistic estimation of a 6% annual growth rate of the installed capacity will lead to the creation of 28.657 person*years during the next 20 years. The estimated 28.657 person*years created correspond to 1.859 full-time jobs, with 748 being in O&M, 706 in construction and 405 in manufacturing.

Due to the nature of the created jobs, construction and O&M jobs created by the European geothermal power industry can be characterized as “European” jobs, as they are covered mainly by the local workforce, while regarding manufacturing of the equipment, the “nationality” of the jobs depends on the origin of the equipment. It is estimated that 85,87% of the total person*years created will involve European workforce.

Apart from the direct jobs, there are also indirect and induced jobs that are created. In order to estimate the total direct, indirect and induced jobs created on a national level, a multiplier of 2 can be used, while a multiplier of 2,5 can be used for the same estimate on a European level. This means that if we have 28.657 person*years created for direct employment during the next 20 years, then on a national level the total direct, indirect and induced person*years will be 57.314 and on a European level we will have 71.643 person*years.

A survey was conducted from December 2011 until August 2013 across Europe involving companies and organizations of the geothermal electricity sector, in order to collect data regarding present and future employment needs, job qualifications and re-specialization needs in the geothermal electricity sector.

Based on the survey results, the most important professions for the geothermal activities of the companies/ organizations are geologists and engineers, while geophysicists, geochemists, technicians, maintainers and drilling consultants are also consider as important professions. Apart from the professions directly related to the geothermal activities, professions such as economic analysts, communications experts, IT experts and accountants are also considered as highly significant.

It is found that employment in the geothermal sector will be higher in 5 years, 10 years and 20 years from now, while the demand for highly skilled workers in the geothermal sector is rising. The geothermal sector suffers from a lack of skilled workers, scientists and researchers. The majority of the companies/ organizations agree that a transfer from another sector to geothermal requires a big amount of retraining, new skill requirements will increase, higher level of skills will be required, there will be need for multi-tasking and multi-skilling, new and hybrid specialties will increase and generic and social skills will be required.

The main professions in which difficulties finding highly skilled personnel are recorded are reservoir and geothermal engineers, as well as drilling consultants and equipment operators. Also, there is a difficulty in finding skilled personnel in specialized geologists, engineers of various specializations, power plant designers and managers, chemists and geoscientists.

It is estimated that the professions that will show the highest demand increase are drilling engineers and drilling equipment operators, specialized geologists, engineers of various specialties (mainly reservoir and geothermal), project and field managers, as well as installers and maintenance technicians.

Employment in the geothermal power industry is expected to increase, while skill gaps and labour shortages may occur. It is very important to adopt policies and projects related to RES that will address the skill gaps and labour shortages issues. A framework of actions is presented, so that possible skill gaps and labour shortages can be prevented and addressed. Some important actions may be: collaboration and coordination between stakeholders, education, up-skilling and re-skilling through continuous education and training, maintaining knowledge, mobility, improving the industry's profile and absorbing workforce of declining industries.

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1. INTRODUCTION

The continuous increase of electric power demand due to global population growth, amelioration of the standard of living, industrialization and urbanization must somehow be addressed, not only because fossil fuels are not infinite, but also because they pollute at a local and global level, thus contributing to the climate change. In this context, geothermal energy is one of the best options to cope with this increasing demand. Development and utilization of geothermal sources offers a range of benefits:

- Provides electricity at a stable price;
- Contributes to the diversification of fuels used for electricity production;
- Promotes national security
- Has minimal environmental impacts and emissions;
- Helps countries to meet their renewable energy use commitments;
- Generates economic development opportunities, especially in rural areas, as well as opportunities for improvement of the local infrastructure.
- Creates new job opportunities, while it favours local employment

Objective of this study is to record the status of the employment of the geothermal electricity sector: estimate the jobs created in the sector and identify the skill gaps and workforce shortages that exist or that may occur.

Specifically, in the 2nd Chapter the disciplines that are needed in the sector -whether we are talking about workforce with low, medium or high skill specialization- are recorded, based on former literature. Also, the disciplines that are needed in each different stage of a geothermal power plant construction are distinguished.

In the 3rd Chapter the number of jobs that can be created in the sector are estimated. Through a literature review, the job creation rates for different employment fields of the geothermal power sector are recorded, while three different scenarios are developed in order to calculate the person*years and the direct full-time jobs that can be created during the next 20 years. The three scenarios differ in terms of the annual growth rate that is taken into account. Also, an estimation of the proportion of the jobs that involve local “European” population is made, while an estimate of the total direct, indirect and induced jobs that can be created at a national and at a European level is also conducted.

The 4th Chapter deals with the skills that are required for the geothermal power sector workforce. Also, an attempt is made to investigate the factors that can create skill gaps and labour shortages, while the problems that gaps and shortages can create are also examined.

In the 5th Chapter the profiles and the results of the survey that was conducted are presented. The survey aimes at European companies and organizations and intends to make estimates on created jobs in the geothermal power industry and identify skill gaps and labour shortages. The survey collects quantitative and qualitative data on employment from these companies and organizations, as well as their perceptions regarding employment and skills in the industry.

Finally, the 6th Chapter proposes a framework of actions, so that possible skill gaps and labour shortages can be prevented and addressed.

2. DESCRIPTION OF JOB TYPES

Types of jobs created

Geothermal energy develops a perspective on the creation of several new jobs. Because of the many different disciplines that are required in the industry, job opportunities are provided for people with different types and levels of skills. Scientists and engineers are needed to explore new geothermal fields. Skilled technicians are required for construction and operation of the new geothermal power plants. Development of EGS (enhanced geothermal systems) technology, can contribute to further creation of jobs through the use of geothermal energy. The jobs created provide a long-term income, for a wide range of different types of jobs, with different level of skills, experience and education, concerning low skilled, medium skilled (technical, skilled crafts, supervisory) and highly skilled (professional and managerial) occupations.

Some of the main areas in which the geothermal power industry can have an impact regarding economic activity and job creation are:

- Suppliers of mechanical equipment and raw material;
- Consultants and contractors searching for geothermal resources;
- Drilling and well service firms;
- Environmental services managing permits and sample testing;
- Geothermal developers, regarding project development, construction, security etc;
- Power plant operators and maintenance staff;
- Scientists for ongoing research and development.

The specialties that may be needed during the development and operation of a geothermal power plant include welders, mechanics, pipe fitters, riggers, plumbers, machinists, electricians, carpenters, drilling engineers, reservoir engineers, construction and drilling equipment operators, surveyors, architects and designers, geologists, geochemists, geoscientists, hydrologists, civil, electrical, mechanical and structural engineers, material scientists, environmental engineers, field operators, managers, attorneys, regulatory and environmental consultants, accountants, computer technicians, researchers, government employees and safety managers.

Table 1. Job types through the project development and operation

Start-up	Exploration	Feasibility drilling	Drilling and Construction	Operation and Maintenance
•Geologists •Biologists •Hydrologists •Archeologists •Lawyers •Paralegals •Environmental engineers	•Geologists •Geophysicists •Geochemists •Engineers •GIS specialists •Exploration drillers •Sample analysts •Consultants	•Drilling engineers •Rig hands •Mud loggers •Drilling fluids personnel •Cementing personnel •Casing crews •Directional drillers •Rig transportation •Fuel transportation •Welders •Safety managers •Geologists •Construction personnel	•Engineers •Power plant designers •Document controllers •Project managers •Construction managers •Project engineers •Field engineers •Safety managers •Welders •Steel erectors •Concrete placers •Assembly mechanics •Inspection personnel	•Plant managers •Engineers •Plant technicians •Site operators •Service repairmen
Enabling activities: IT professionals, Human resource professionals, Health and safety consultants, Administration, Insurer representatives, Management, Government office workers, Educators and trainers, Accountants, Auditors, Financers, Publishers and Science writers				

Source: Based on GEA [1] and ILO [2]

The number of people associated with the development of a geothermal project is not always obvious. Development of geothermal resources requires the support of many skilled laborers and professionals during different stages of resource development. The operation of the power plant represents a small fraction of the generated employment. The development of a power plant starts quite before the construction phase, and requires the involvement of many different job types. Most specialties are required only in a specific phase, and not throughout the whole development of the project. In order to categorize the specialties needed in each task, the development of a geothermal power plant could be

categorized into six different phases, plus the enabling activities that are needed during the whole project (Table 1).

A GEA study [1] identifies the different types and number of jobs needed during each phase of a geothermal power plant development. According to this study, the development of a typical geothermal power plant may require up to 860 different people (Table 2).

Table 2. Jobs involved in Geothermal Development (50 MW)

Stage of development	No. of jobs
Start-up	10-13
Exploration	11-22
Drilling	91-116
Plant Design and construction	383-489
Operation and maintenance	10-25
Power plant system manufacturing	192-197
Total	**697-862**

Source:GEA [1]

During the phases of a power plants development and operation, a big number of professionals and technicians is required. Following, the specialties needed in each phase are being examined.

Job types required during start-up phase

This is the preliminary development phase, which involves actions that must be taken even before the exploration stage. Most of the work is realized in offices, where professionals like geologists, environmental engineers and consultants, biologists, hydrologists and archeologists prepare the required environmental impact assessments, studies and documents needed to get permission for exploration. During these actions, specialties like lawyers and paralegals are also needed. Professionals that are occupied during this phase can also be occupied during later phases of the project, when studies may be also required. According to [1], during this phase 10-13 different people may work on the project.

Job types required during exploration phase

During this phase, exploration of the geothermal field is conducted, so that the planning of drilling and production well locating can be made. Exploration activities may require

professionals with many years of experience, like geologists, geophysicists, geochemists, engineers and GIS (geographical information system) specialists. Persons for the collection and recording of data coming from exploratory drilling and geophysical tests are needed, while consulting and management professionals are required in order to evaluate these findings. Also, clerical staff and management employees are also important in this phase. Based on the findings of [1], during this phase 11-22 different people are required

Job types required during drilling

When the exploratory phase has been completed, the drilling process begins. It is usual to hire a specialized crew for this task. During this phase experienced personnel is needed in specialties like engineers, geologists, welders, rig hands, cementing personnel, safety managers, site managers. Also, the processes taking place during this phase need support from administrative and managerial teams that manage and support the operations. Based on [1], 91-116 different people may be needed during this phase.

Job types required during design and construction

This phase deals with the design and construction of the power plant. During this phase, apart from the construction company, subcontractors may be used for specific tasks that require a high level of specialization. During the engineering and design phase 43-49 may be needed according to [1], while the required specialties include engineers, plant designers, supervisors, administrative support. During the construction of the power plant 300-400 different people may be needed ([1]- for a 50 MW geothermal power plant). The specialties needed during this phase may include construction managers, project engineers, field engineers, safety managers, administrative support, welders and assembly mechanics, skilled construction workers. The construction of the power plant takes about 2,5 years. During this period the number of people occupied may vary, with the number of people occupied being small in the begging and growing as the project progresses. For smaller projects the number of occupants is reduced, but not in the same rate that the size (MW) of the project is reduced. For example, according to [1], for a 25 MW power plant (50% smaller) the number of occupants will be reduced by 25%.

Job types required during manufacturing

The geothermal power plants require a big number of different equipment that must be manufactured apart from each other, and subsequently connected to each other. The manufacturing process occupies specialties like mechanical engineers, electrical engineers, system engineers, quality and manufacturing engineers, maintenance engineers, software engineers, procurement specialists, mechanists, electricians, welders, assembly mechanics, manufacturing operators and technicians, inspection personnel, logistic professionals and shipping personnel. A standard 7 MW geothermal power unit supports 165 jobs [1], while a 50 MW power plant uses 7 such units and a lot of different equipment.

Job types required during operation and maintenance

When the power plant stars to operate, personnel for its operation and maintenance is employed. Some of the job types needed may be power plant managers, engineers, maintenance technicians, site operators, measurement and control engineers and energy management technicians. According to [1], 10-25 people are employed during this phase. Apart from the permanent jobs created, we should take into account that the different manufacturers are responsible for the maintenance of the different equipment that has been installed. This means that each manufacturing company usually sends its own maintenance crew, thus leading to even more jobs created.

Job types required by enabling activities

During the whole timeline of a projects development, from the start-up phase to its operation and maintenance, some specialties that organize, advise and assist the different tasks are needed. Such professions may be human resource professionals, accountants, auditors, financers, health and safety consultants, sales/marketing, information technology specialists, management and administration professionals and insurer representatives.

Total employment tends to increase in jumps, when a significant new installation is commissioned. Regarding the patterns of employment for the different phases, project development, contsruction and installation are project based, so continuity of employment depends on a fairly steady flow of projects. Manufacturing is similar to other capital investment goods industries, while operation and maintenance patterns of employment are more stable. These characteristics apply especially to larger projects, meaning that they are

more visible in the geothermal power plant industry, rather than e.g. in the geothermal heat pump industry, where demand smoothens over time.

Besides, if a country or a region gets involved in the manufacturing sector, the local economy can benefit even more, through the export of the manufactured equipment. When a geothermal plant is designed and constructed, expenses are made for services and equipment, while taxes and royalties are also paid. Also, the indirect taxes increase due to the indirect development of the economy. These expenses enhance the creation of additional indirect jobs, development of the economic activity and a further increase of collected taxes.

3. EMPLOYMENT IMPACT ESTIMATES

Employment impacts of the geothermal power industry development can be analyzed not only regarding their quality characteristics, but and in relation to the quantitative impacts that may occur. According to GEA [3], in 2004 the geothermal industry in U.S.A. provided 4.583 direct jobs, which correspond to 1,7 jobs per MW of geothermal capacity installed. Based on the same study, on-site construction typically concerns 3,1 person * year jobs per MW, manufacturing 3,3 person * years per MW and O&M 0,7 jobs per MW of geothermal capacity installed.

A more recent study conducted by the Institute for Sustainable Futures [4] uses weighted averages from employment data of thirteen power stations totalling 1.050 MW in order to estimate the construction and O&M factors regarding job creation, while it uses the same manufacturing factor (3,9) as GEA [3]. Their estimates give a factor of 6,8 person * years per MW for construction and 0,36 jobs per MW for O&M. More detailed data regarding the projects this study has taken into consideration can be found in Table 3.

Table 3: Geothermal employment factors

Region/ country	Year	Construction Person years/MW	Manufacturing Person years/MW	O&M Jobs/MW	Build time Years	MW
Current report		**6,8**	**3,89**	**0,36**		
US	2012	5,5		0,2	4,0	260
US	2011			0,4		235
US	2012			0,5		159

US	2009	8,8			2,8	60
US	2010	11,35	3,89	0,35	2,5	50
US	2011	10,0		0,3		50
US	2011			0,7		50
US	2009?			0,3		48
US	2011	12,5		0,5		30
US	2006	3,2		0,6		26
Australia	2009	9,3		0,2		24
Australia	2009	6,0		0,2		50

Source: Institute for Sustainable Futures [4]

In order to compare the above data with another energy providing sector, we can mention that a geothermal power plant provides significantly more jobs than a comparative natural gas-fired power plant, according to the Institute for Sustainable Futures [4] and the U.S. Department of Energy (DOE) [5], as seen in Table 4.

Table 4: Comparison of employment factors

	Construction/installation job years/ MW	**Manufacturing job years/ MW**	**O&M Jobs/MW**
Gas	**1,7**	**1,0**	**0,08**
Geothermal	**6,8**	**3,9**	**0,4**

Source: Institute for Sustainable Futures [4]

Projections of installed capacity

According to Karytsas and Mendrinos [6] the EU geothermal power industry comprises to 941 MW and during the next years is expected to show an average 6% annual growth rate. The megawatts that are expected to be installed during the next 20 years, based on the estimation mentioned above, are presented in Table 5. Three different scenarios are investigated, with each one taking into consideration a different growth rate of the installed capacity. The first scenario uses a 6% growth rate, which, according to [6] is "business as usual". In addition to the "business as usual" scenario, the next two scenarios assume more optimistic growth rates, 10% and 15% respectively. These two scenarios represent a more favorable development of the geothermal power sector that may occur due to technology, market conditions and policies.

Table 5: Projections of new capacity during the next 20 years (MW)

Year	**Scenario I (6%)**	**Scenario II (10%)**	**Scenario III (15%)**

2013	56,46	94,10	141,15
2014	59,85	103,51	162,32
2015	63,44	113,86	186,67
2016	67,24	125,25	214,67
2017	71,28	137,77	246,87
2018	75,56	151,55	283,90
2019	80,09	166,70	326,49
2020	84,89	183,37	375,46
2021	89,99	201,71	431,78
2022	95,39	221,88	496,55
2023	101,11	244,07	571,03
2024	107,18	268,48	656,69
2025	113,61	295,33	755,19
2026	120,43	324,86	868,47
2027	127,65	357,34	998,74
2028	135,31	393,08	1.148,55
2029	143,43	432,39	1.320,83
2030	152,03	475,63	1.518,95
2031	161,16	523,19	1.746,80
2032	170,83	575,51	2.008,81
Total	**2.076,91**	**5.389,58**	**14.459,91**

After having estimated the capacity that will be installed during the next 20 years, we can use the coefficients from Table 3, in order to estimate the new jobs created in power plant construction, equipment manufacturing and operation & maintenance, due to the further growth of the sector. For manufacturing jobs we use the coefficient 3,9, for construction jobs 6,8 and for O&M 0,36.

According to the estimates presented in Table 6, a 6% growth rate of the annual installed capacity during the next 20 years can create a total of 28.657 person*years. It is better to express the jobs created using this metric unit, due to the temporary nature of manufacturing and construction jobs. Based on Table 6 and Figure 1 we can see that with a 6% annual growth of installed capacity, the total annual employment impact will rise from 624 person*years to 2.576 person*years.

Table 6: Estimation of annual employment impact – Scenario I (person*year unit)

Year	New capacity (MW)	Construction jobs	Manufacturing jobs	O&M jobs	Total annual employment impact
2013	56,46	384	220	20	624
2014	59,85	407	233	42	682
2015	63,44	431	247	65	744
2016	67,24	457	262	89	808

2017	71,28	485	278	115	877
2018	75,56	514	295	142	950
2019	80,09	545	312	171	1.028
2020	84,89	577	331	201	1.110
2021	89,99	612	351	234	1.196
2022	95,39	649	372	268	1.289
2023	101,11	688	394	304	1.386
2024	107,18	729	418	343	1.490
2025	113,61	773	443	384	1.599
2026	120,43	819	470	427	1.716
2027	127,65	868	498	473	1.839
2028	135,31	920	528	522	1.970
2029	143,43	975	559	573	2.108
2030	152,03	1.034	593	628	2.255
2031	161,16	1.096	629	686	2.411
2032	170,83	1.162	666	748	2.576
Total	**2.076,91**	**14.123**	**8.100**	**6.434**	**28.657**

Based on Figure 1 we can note that over time total annual O&M jobs override total manufacturing jobs, and tend to approach the number of total annual construction jobs created.

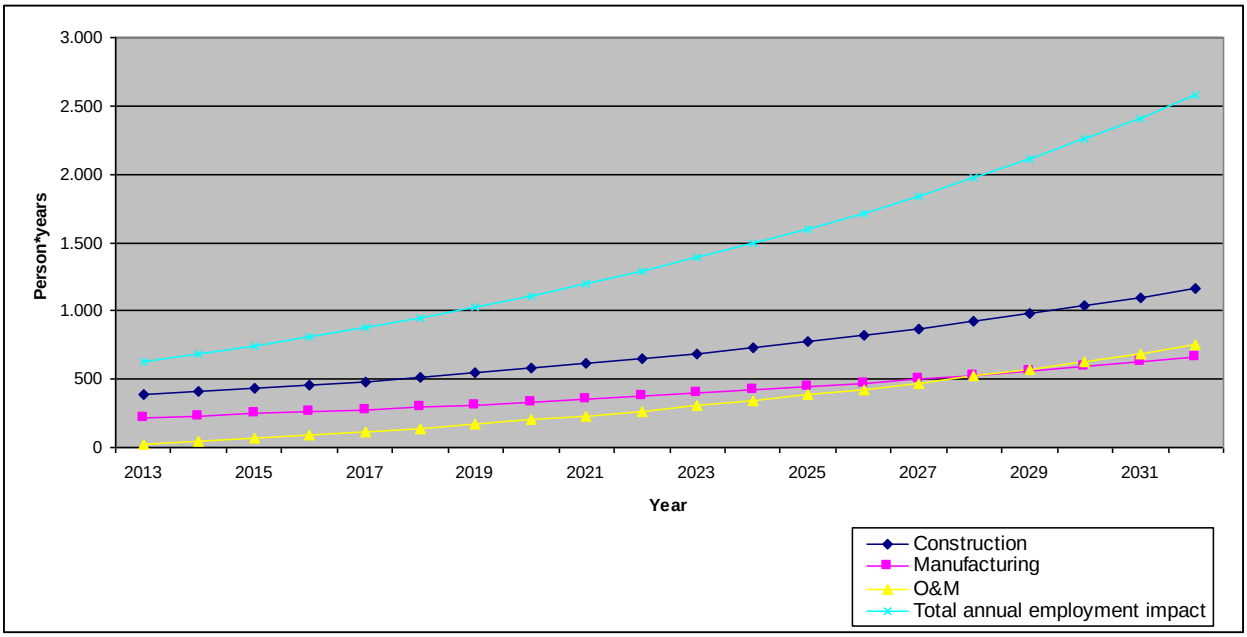

Figure 1. Estimation of annual employment impact - Scenario I (person*year unit)

Assuming that temporary short-period jobs (construction and manufacturing) are equally distributed in time, then we can express the person * years in fulltime jobs. This means that according to the assumptions of Scenario I, the 28.657 person*years correspond to 1.859

full-time jobs. We can calculate this by dividing total manufacturing and construction jobs by 20 (the number of years) and adding the total number of permanent O&M jobs created. By converting person*years to fulltime jobs, it is indicated that the most favored category is O&M. After 20 years of development the total number of fulltime jobs created in this category will be 748, while 706 full-time jobs in construction and 405 full-time jobs in manufacturing will be created, as seen in Figure 2. The total number of O&M jobs is higher than the other two categories, as we are dealing with permanent jobs that do not depend on each year's development. Operation and maintenance of the power facilities may be permanent jobs, but on the other hand construction and maintenance employment is temporary and is totally related to the annual industry growth, namely the projects that are realized each year. This distribution of jobs is beneficiary for the total employment situation, as O&M jobs continue to exist even if no new projects are developed. This means that if in the year 2032 the installation capacity rate of geothermal plants turns to 0%, meaning that there are no new projects developed, 748 permanent and fulltime jobs will remain due to O&M employment. Here, it should be also mentioned that manufacturing employment related to O&M (e.g. equipment replacement) is considered as indirect employment, so it isn't taken into account in this analysis.

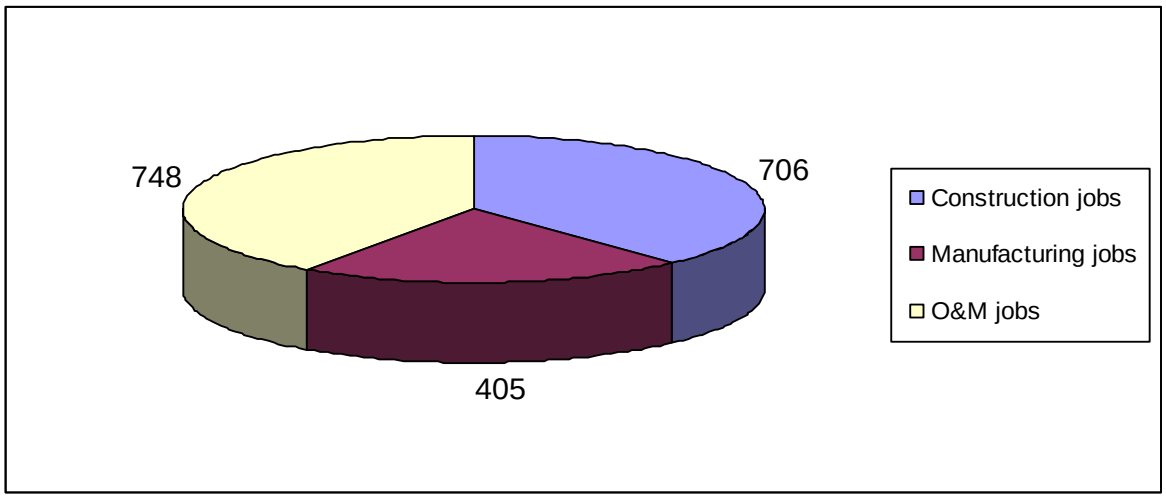

Figure 2: Total fulltime jobs created – Scenario I

In Scenarios II & III the annual employment impact is estimated, taking into account development rates higher than the "business as usual rate", that is 6%. For Scenario II the annual capacity installation rate is 10% and for Scenario III it is 15%.

According to the findings of Scenario II (Table 7), a 10% annual growth rate can create a total of 72.236 person*years. This means that the 1.041 person*years of 2013 will become 8.098, 20 years later, in 2032. If we want to express these numbers in fulltime jobs, for O&M 1.940 fulltime jobs will be created, for construction 1.832 and for maintenance 1.051 fulltime jobs.

Table 7: Estimation of annual employment impact – Scenario II (person*year unit)

Year	New capacity (MW)	Construction jobs	Manufacturing jobs	O&M jobs	Total annual employment impact
2013	94,10	640	367	34	1.041
2014	103,51	704	404	71	1.179
2015	113,86	774	444	112	1.330
2016	125,25	852	488	157	1.497
2017	137,77	937	537	207	1.681
2018	151,55	1.031	591	261	1.883
2019	166,70	1.134	650	321	2.105
2020	183,37	1.247	715	387	2.350
2021	201,71	1.372	787	460	2.618
2022	221,88	1.509	865	540	2.914
2023	244,07	1.660	952	628	3.239
2024	268,48	1.826	1.047	724	3.597
2025	295,33	2.008	1.152	831	3.991
2026	324,86	2.209	1.267	948	4.424
2027	357,34	2.430	1.394	1.076	4.900
2028	393,08	2.673	1.533	1.218	5.424
2029	432,39	2.940	1.686	1.373	6.000
2030	475,63	3.234	1.855	1.545	6.634
2031	523,19	3.558	2.040	1.733	7.331
2032	575,51	3.913	2.244	1.940	8.098
Total	**5.389,58**	**36.649**	**21.019**	**14.568**	**72.236**

As for Scenario III (Table 8), a 15% annual growth rate will result to 187.855 person*years. This means that the 1.561 person*years of 2013 will become 26.700 person*years in 2032. If we want to express these numbers in fulltime jobs, for O&M 5.206 fulltime jobs will be created, for construction 4.916 and for maintenance 2.820 fulltime jobs through geothermal sources development.

We should mention again that in any Scenario examined, the total employment of the industry mostly benefits from the permanent O&M jobs created.

Table 8: Estimation of annual employment impact – Scenario III (person*year unit)

Year	New capacity	Construction	Manufacturing	O&M	Total annual

	(MW)	jobs	jobs	jobs	employment impact
2013	141,15	960	550	51	1.561
2014	162,32	1.104	633	109	1.846
2015	186,67	1.269	728	176	2.174
2016	214,67	1.460	837	254	2.551
2017	246,87	1.679	963	343	2.984
2018	283,90	1.931	1.107	445	3.483
2019	326,49	2.220	1.273	562	4.056
2020	375,46	2.553	1.464	698	4.715
2021	431,78	2.936	1.684	853	5.473
2022	496,55	3.377	1.937	1.032	6.345
2023	571,03	3.883	2.227	1.237	7.347
2024	656,69	4.465	2.561	1.474	8.500
2025	755,19	5.135	2.945	1.746	9.826
2026	868,47	5.906	3.387	2.058	11.351
2027	998,74	6.791	3.895	2.418	13.104
2028	1.148,55	7.810	4.479	2.831	15.121
2029	1.320,83	8.982	5.151	3.307	17.440
2030	1.518,95	10.329	5.924	3.854	20.106
2031	1.746,80	11.878	6.813	4.482	23.173
2032	2.008,81	13.660	7.834	5.206	26.700
Total	**14.459,91**	**98.327**	**56.394**	**33.134**	**187.855**

“European” jobs created

Due to the nature of the created jobs, we can assume that needs regarding construction and O&M are covered by local workforce, while manufacturing jobs may be created internationally, depending on where the industries manufacturing the applicable equipment are located. This means that construction and O&M jobs created by the European geothermal power industry can be characterized as “European” jobs, while regarding manufacturing of the equipment, the “nationality” of the jobs depends on the origin of the equipment.

So, in order to estimate the “nationality” of the potential jobs created, and based on the results of Scenario I we can assume that regarding construction, 100% of the 14.123 person*years created will remain “European”, while we can assume the same for the 6.434 person*years created in O&M. Regarding manufacturing jobs, we can make an assumption that 50% of the equipment will be manufactured in Europe and the rest in other countries. If we assume that the labour intensity is the same in all the manufacturing industries, then we can conclude that half of the 8.100 person*years corresponding to manufacturing jobs will

remain “European”. This means that 24.607 person*years from a total of 28.657 person*years created will remain “European”, meaning that 85,87% of the total person*years created will involve European workforce.

As the percentage estimated depends entirely on manufacturing employment, alternations (increase/decrease) of the supply of equipment manufactured in Europe can affect the above estimations respectively. These alternations may occur due to technological changes, policies, business strategies, financial motives etc.

Direct, indirect and induced jobs

Direct jobs:

These jobs are associated to the core activities of an industry, such as project development, site preparation, installation, operation and maintenance. During the construction phase, direct employment corresponds to the total jobs associated with the construction, while during the operation and maintenance phase, it relates to all jobs associated with the power plant O&M. There is always the possibility that each country has a different definition on which jobs are considered direct, making it difficult make comparison between different countries. According to Kammen et al. [7] "direct employment includes jobs created in the manufacturing, delivery, construction, installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration".

Indirect jobs:

Indirect jobs include jobs from industries that supply goods and services to geothermal power plant construction, operation and maintenance. The range of these jobs is extensive and would include government regulators, R&D professionals, lawyers, architects, equipment service personnel, business management personnel, security guards, etc.

Induced jobs

Induced jobs are created when wealth generated by the industry, directly or indirectly, is spent elsewhere in the economy, thereby stimulating demand in sectors that may be completely unrelated to geothermal power.

Employment multipliers regarding indirect and induced impacts

An investment in a particular sector of the economy has indirect and induced impacts on other sectors. In order to calculate these impacts "Input-Output Models" are used, which describe economic relationships between different sectors. The multipliers can be used to determine the relationship between direct, indirect and induced impacts. We must take into account that the indirect impacts of a construction depend on the size and characteristics of every different economy. The larger the size of the economy, the larger the values of the multiplier will be. Also, a difference may exist regarding the values of the multipliers, in the phase of construction and the O&M phase. Table 9 lists some multipliers are that have been estimated and reported in literature. These multipliers include both indirect and induced values. It should be noted that calculation of indirect and induced employment impacts through multipliers can not be done with total accuracy, as it is not stated whether the employment impacts are permanent or temporary.

The values of these multipliers actually correspond to monetary units. For example, based on Table 9, the expenditure of 1$ on a geothermal power project will offer a total growth of 2,5$ to the economy. To interpret these results into employment impacts is a complex process, as each industry has specific labour intensity.

Table 9. Economic Impact Multipliers for Geothermal Power Project Investment

Year	Economy size	Type of expenditure		
		Non-Specified	Construction	O&M
1989	Nevada		1,74	1,3
1991	1 county (OR)	1,2		
1994	California USA	2,0-2,1 2,5		
2002	4 counties (CA)		1,61	1,74
2003/2004	Nevada	1,72		

Source: GEA [3]

An approach for the calculation of indirect and induced employment impacts, as suggested by Lesser [8], is to apply directly the multipliers to the values of direct employment. Based on Table 7, we can assume that if we want to make an estimate on a national level we should use a multiplier of 2, while if we want to make an estimation on a European level, we

should use a value of 2,5. This means that if we have 28.657 person*years (Scenario I) created for direct employment during the next 20 years, then on a national level the total direct, indirect and induced person*years will be 57.314 and on a European level we will have 71.643 person*years (Table 10).

Another method for calculating employment impact is to express the economic value into number of jobs created, depending on the type of economic sectors that benefit from the increase in consumption. This method can give higher employment impacts than the previous method used, while the previous method gives estimations closer to reality.

Table 10: Total direct, indirect and induced employment impacts (Scenario I)

	20 years
New MW installed	2.077
Direct person*years	28.657
Indirect and induced person*years – national level	28.657
Indirect and induced person*years – European level	42.986
Direct, indirect and induced person*years– national level	57.314
Direct, indirect and induced person*years– European level	71.643

4. SKILL GAPS

Necessary skills for the geothermal power sector workforce

During all stages of development and operation of a geothermal power plant professionals and technicians with high, intermediate and low skills are required. The required skills are specialized for the sector, although some of them may be similar to those required in the conventional power generation industry. Basic qualifications necessary for the industry are graduate degrees and work experience. A postgraduate degree, internship in a power plant, management or administration degree and skills are also desirable.

Apart from the above basic skills, the existence of possesing a range of other generic skills is important. Environmental information and awareness, motivation, leadership skills, work in team environment, good communication, presentation skills, seeking learning activities, analytical skills, quick adjustment to varying tasks, continuous knowledge acquisition, overall understanding of company process and entrepreneurial thinking are greatly desirable for employees at all levels. Managers and professionals must also possess dynamism, negotiating and strategic skills so that they can take advantage of the market opportunities opening up to them.

Skill gaps and labour shortages

Transition to a "green" economy can create demand for workforce and high skilled professionals and technicians. The increased demand, which may possibly increase even more in the future [9] is very likely not be able to be adequately covered, creating recruitment problems in the sector. Skill gaps and labour shortages created may lead to:

- Higher wages;
- Increased production costs;
- Lower productivity of workers and machinery;
- Sets limits to the production;
- Creates delays to the projects;
- Missed opportunities;
- Lower reliability;
- Lower quality output;
- Worse safety conditions;

- Limit the development of the industry.

What creates skills gaps and workforce shortages?

Some specialized skills and occupations are always in high demand regardless of the industry and the situation of the economy. In the geothermal power industry, some kinds of skills and occupations are so specialized, or in such a short supply, that they have to be drawn on a global scale.

The current economic situation may have reduced energy demand and has affected negatively the construction industry, thereby reducing the demand for energy related occupations. This is why some of the skill and workforce shortages might not be currently visible. But it is not clear what will happen, and how the educational and training sector will react when demand increases.

The lack of qualified workforce, as well as the skill gaps that occur may be created when the activity of the industry increases rapidly. These skill shortages are more likely to be less severe in countries that already have a highly skilled workforce.

Also, technological development creates a continuous source of demand for skilled personnel in research and technology, as well as in the use of new equipment and machinery. This may imply that one of the reasons that demand raises is due to the change of the skills type, rather than the increase of the number of individuals needed. Another influencing factor is that the technology in the industry grows so rapidly, that education and training in many cases cannot follow the developments.

Other reasons that may affect the creation of skill gaps or labour shortages are ineffective recruitment practices, work organization, wage policies and working conditions. Also, the number of people that selects relevant studies is not sufficient, while another issue may be that employers have no incentive to educate young people since after the training they may shift to another company or sector. Problems may be created due to the insufficient matching between gaps and individuals that are qualified and looking for work.

Moreover, shortages can be created due to the retirement of professionals and technicians, whose gaps are not filled in because young people do not have the willingness or the skills to replace them. Besides, in many cases it is difficult to attract young people into practical, manual work which incorrectly may have a bad “profile”.

Observed skill and workforce gaps

According to older studies skill shortages in areas such as technical, leadership, project management, managerial, scientific, marketing, and generic skills exist [9],[10],[11],[12]. Regarding to the lack of professionals, there is a gap in engineers and technicians in all categories of RES, as well as in skilled trade workers. A shortage also occurs in certified engineers (civil, mechanical and electrical) with expertise in specific RES technologies. Specifically, for the geothermal industry, occupations difficult to fill in are geothermal engineers and trainers.

There are also skills shortages in non-technical jobs. For example, in many countries, accounting and finance staff, management and executives, surveyors, auditors, lawyers, and people that work on financial investments do not have the proper skills that are important for the development of the industry.

5. SURVEY RESULTS

Objective of this study is to make estimates on created jobs in the geothermal power industry and identify skill gaps and labour shortages. A survey was conducted in order to collect data regarding present and future employment needs, job qualifications and re-specialization needs in the geothermal electricity sector. The questions that concern data that change from year to year, refer to data of the year 2011.

In order to conduct the survey, a questionnaire entitled: "Questionnaire: Employment in geothermal electricity sector" was created. The questionnaire was divided into three sections:

i) Company/Organization information;

ii) Employment in company/organization;

iii) Employment perceptions and qualities.

The full questionnaire can be found in the Appendix.

The questionnaire was sent to geothermal power companies and organizations and was published online on the GEO ELEC project website. More specifically, the questionnaires were distributed and collected:

- during Milan Workshop, 05.12.2011;
- during Athens Workshop, 20.12.2011;
- through GEO ELEC Partners;
- to EGEC Members;
- through APPA (Spanish Renewable Energy Association) Members;
- during EGC 2013, Pisa 3-7 June;
- through EGEC.

The results of the data collected through the survey from December 2011 until August 2013 are presented bellow.

General information of participants

A total of 55 companies and organizations from 16 different European countries participated in the survey. As seen in Figure 3, 12 (21,82%) entities from Spain, 9 (16,36%) from Germany,

6 (10,91%) from Italy, 3 (5,45%) from France and Switzerland, 2 (3,62%) from Austria, Belgium, Czech Republic, Greece, Hungary, Iceland, Slovakia, The Netherlands and UK, as well as 1 (1,82%) from Denmark and Estonia participated from each of the countries. Two (3,64%) entities stated that they are multinational.

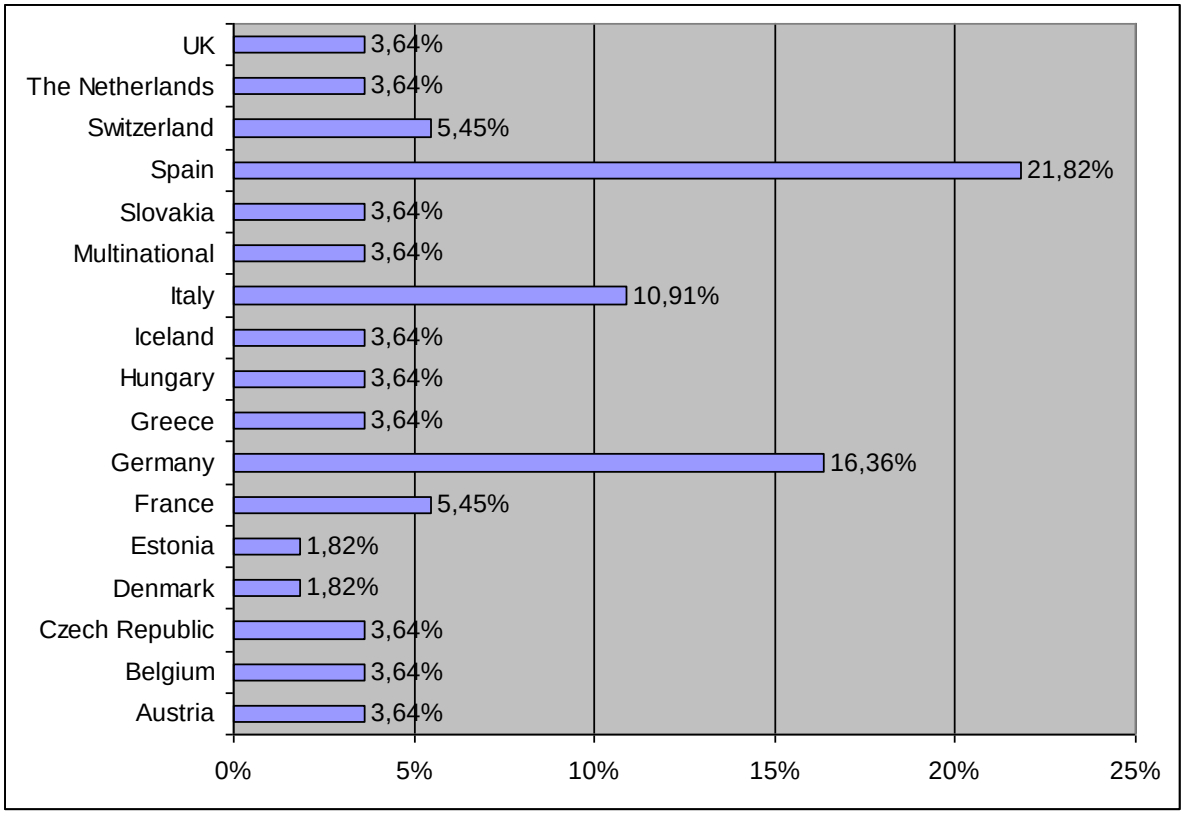

Figure 3. Base countries of companies/organizations

Among the 55 participants, 42 answered the question regarding whether they are also active in other countries, apart from their base-country. Twenty seven (64,29%) of them responded that they operate in other countries, while 15 (35,71%) responded that operate only on a national level (Figure 4). The entities that are also active in other countries noted that they are mainly active in the countries of EU and Europe in general, while there is also activity from some of them in the U.S., Australia, and various countries of the Caribbean, Latin America, Africa and Asia.

The question about whether the company/organization is also active outside the geothermal sector had 46 responses. The majority of the entities, namely the 76,09% (35 entities), stated that are active in fields outside the geothermal sector, while 23,91% (11) operate exclusively in the geothermal sector (Figure 5). Regarding the percentage of activities that geothermal energy represents, there were 25 replies from the respondents that are also active in other

areas. Based on those responses, the average percentage that geothermal activities represent is 26,44%, with the median of this percentage being 12%.

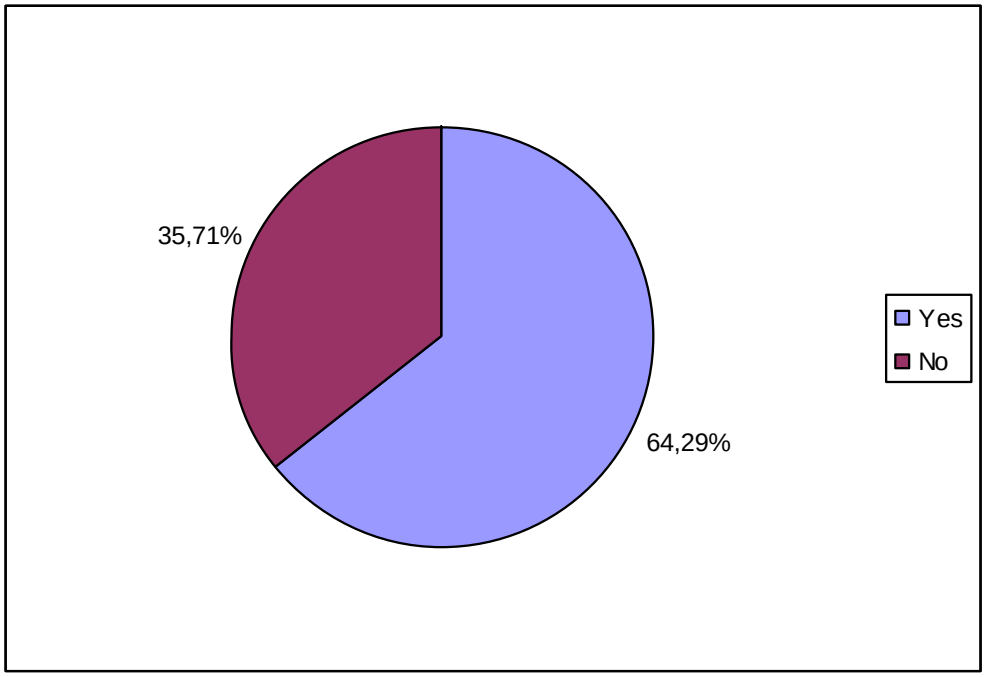

Figure 4. Companies/ organizations active in other countries

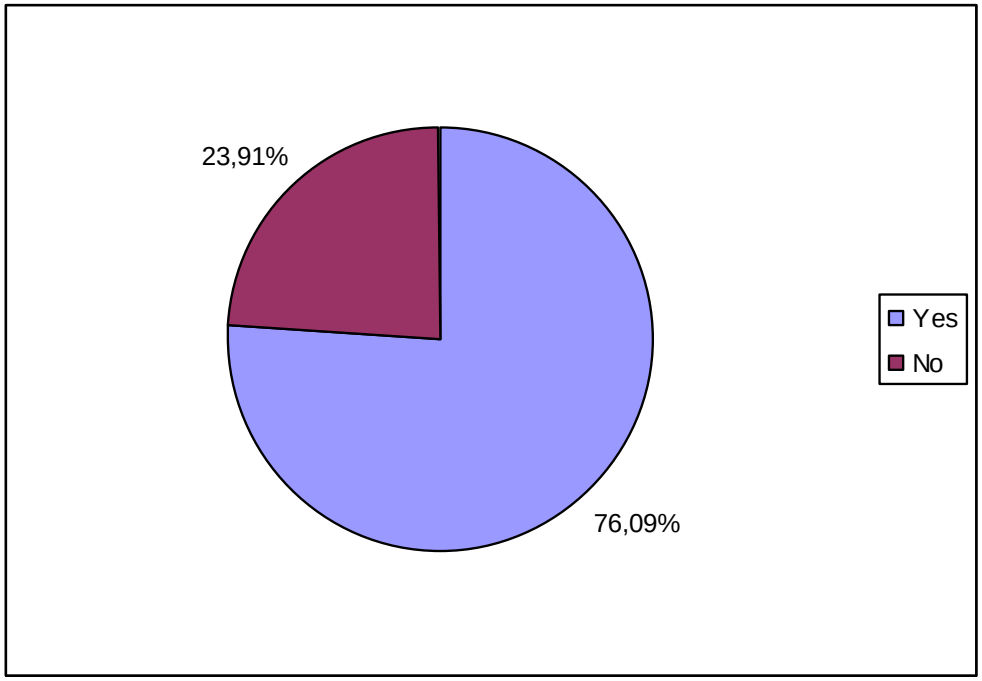

Figure 5. Companies/ organizations active outside the geothermal sector

Regarding on whether the companies/organizations own other entities involved in the geothermal sector, 17,78% (8) responded positively, while the majority (37) answered that doesn't own other entities active in the sector, in a question that included a total of 45 responses (Figure 6).

The question regarding the ownership of geothermal power plants was answered by 45 participants (Figure 7). The answers show that 20% (9) own geothermal power plants, while the remaining 80% (35) answered negatively to the question. Between the nine companies stating that own geothermal power plants, six also recorded the total installed net capacity of the power plants. The mean of these values is 257,25 MW, while the median is 9,5 MW.

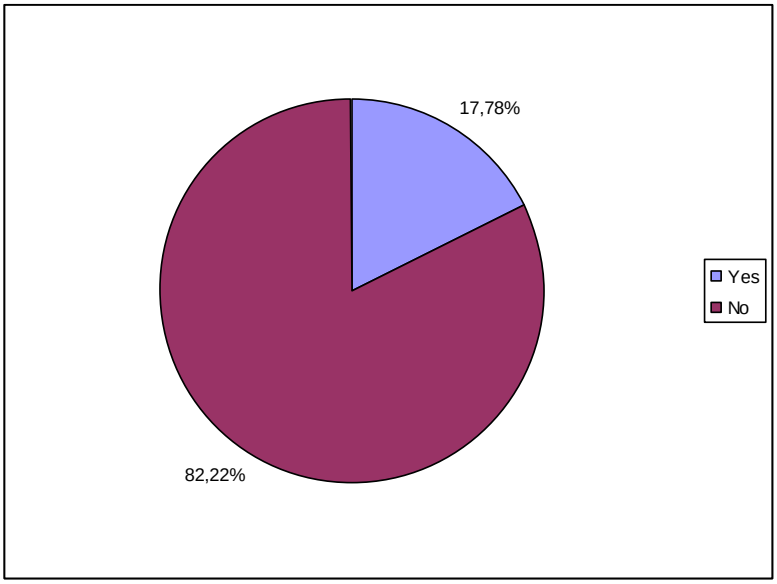

Figure 6. Companies/organizations that own other entities involved in the geothermal sector

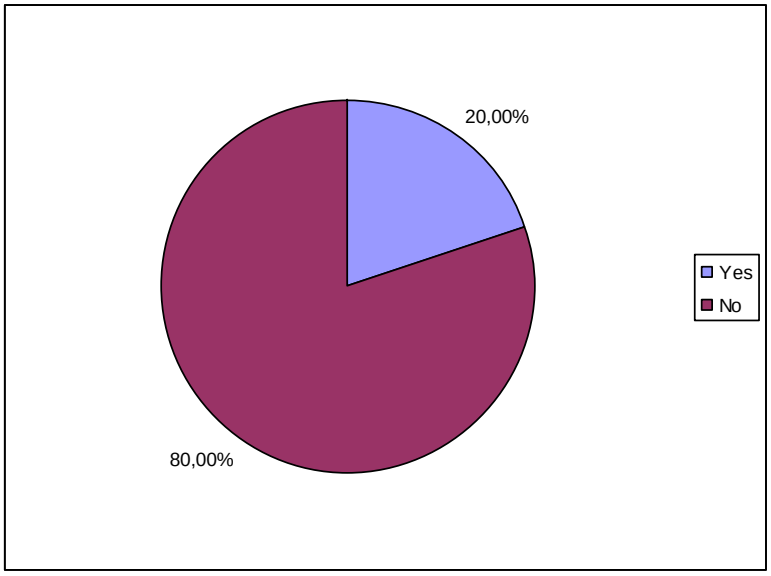

Figure 7. Companies/ organizations that own geothermal power plants

The participants were questioned about the types of business their company/organization is involved in. The question was answered by all 55 participants, while the results are presented in Figure 8. The type of business in which most participants are involved with is research and development, with 69,09% (38) of the entities having activity in it. More specifically, research and development activities of the companies and organizations involve subjects as geothermal electricity, geothermal heating and cooling, GSHP, EGS, deep drilling technologies, ORC, thermal piles, adsorption technologies, thermal direct uses, fluid dynamics and thermodynamics, improved exploration and resource assessment techniques. A high percentage is also active in consulting, in particular 52,73% (29), in objects such as geological exploration and field development, planning of drilling site, reservoir development and casing design, feasibility studies, geological and technical due diligence studies, geological modeling and reservoir engineering, geological evaluation and resource assessment and permit procedures. The 41,82% (23) is active in education, while with electrical energy production 40% (22). Also, 29,09% (16) is involved in non-electrical applications, 27,27% (15) in drilling activities, 25,45% (14) in operation and management of geothermal field, 20% (11) in construction of geothermal fluid collection, transmission & distribution system and operation and maintenance of power facilities, 14,55% (8) in construction/manufacturing of power plants, while 12,73% (7) in active as equipment suppliers. Moreover, 29,09% (16) of the companies and organizations are engaged in various other activities, including district heating operators, electric transmission, environment,

finance, governmental relations and regulations, impact assessment and feasibility studies, legal, planning, publishing, reservoir design and development, resource exploration and assessment and supporting services.

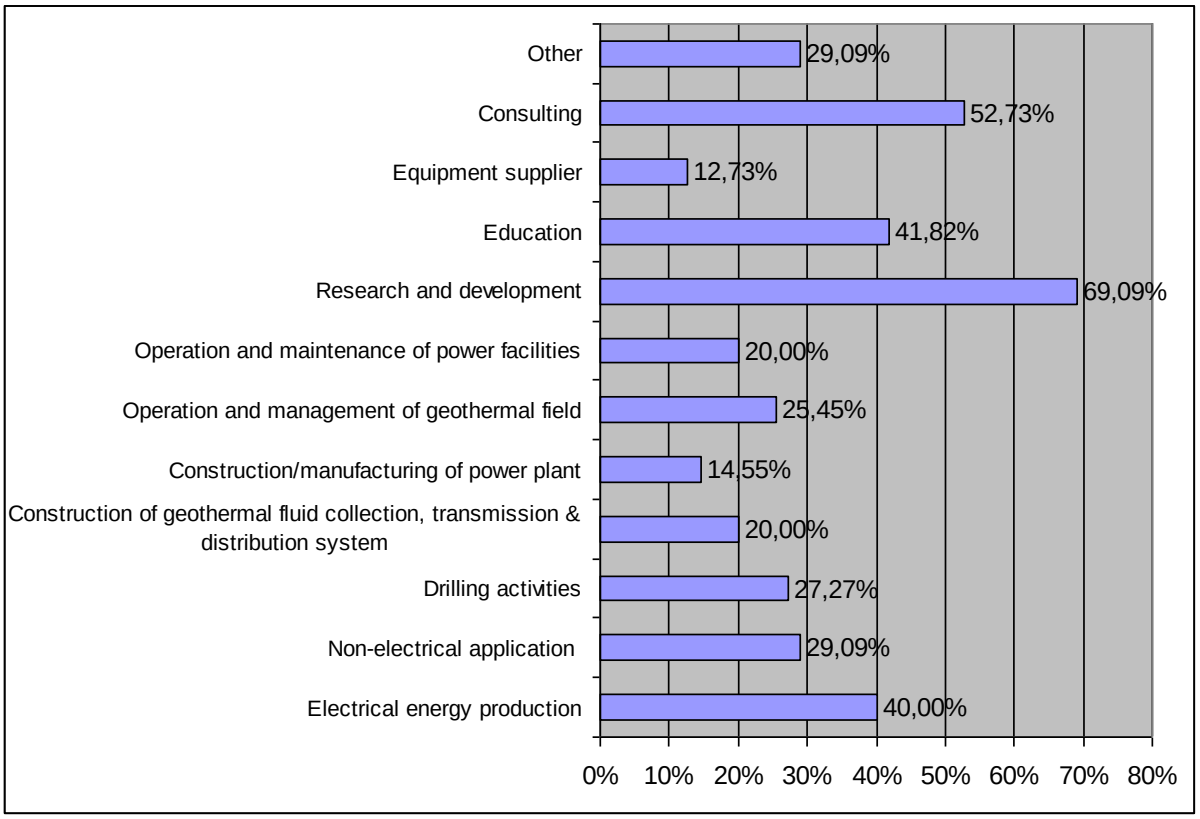

Figure 8. Types of business that companies/ organizations are involved in

Employment in company/organization

When asked about the total number of employees in their company/organization, 44 of the participants responded. Specifically, the participants where asked to take into consideration only employees working directly for their company/organization during the year 2011, without taking into account contractors and consultants. The mean value of total employees among the 44 entities is 8.187, while the value of the median is 70 employees. Using the value of the median may be a better way to export more rational conclusions compared to using the value of the mean, as extreme values (entities with a very high or a very low number of employees) may create distortions in relation to reality. The number of employees working in the geothermal sector activities of these entities has a mean value of 21,17, while the median has the value of 6. As above, using the value of the median may

lead to safer conclusions. Based on the values of the medians, it is estimated that approximately 9% of the total employees of the participating entities are involved in the geothermal sector activities. This value is consistent with the 12% value, which has been mentioned above and represents the percentage of activities that geothermal energy represent, in relation to the total activities of the companies/organizations, in the cases that they do not exclusively operate in the geothermal sector.

Referring to the number of full-time and part-time workers engaged in activities related to the geothermal sector, 39 and 37 entities responded respectively. The mean of full-time workers is 21,18 and the median 5, while with regard to part-time workers, the mean is 2,54 and the median 1. Based on the values of the medians, it is detected that 85% of the employees involved in the geothermal sector activities are full-time employees, while the rest 15% are part-time employees.

In another question concerning employees' characteristics, the participating entities were asked about the job location of their employees. Through this question, which was answered by 34 entities, it is indicated that the highest percentage of employees is working at a national level (47,1%), 35,1% works at a local level, while 17,8% of the employees is active internationally (Figure 9).

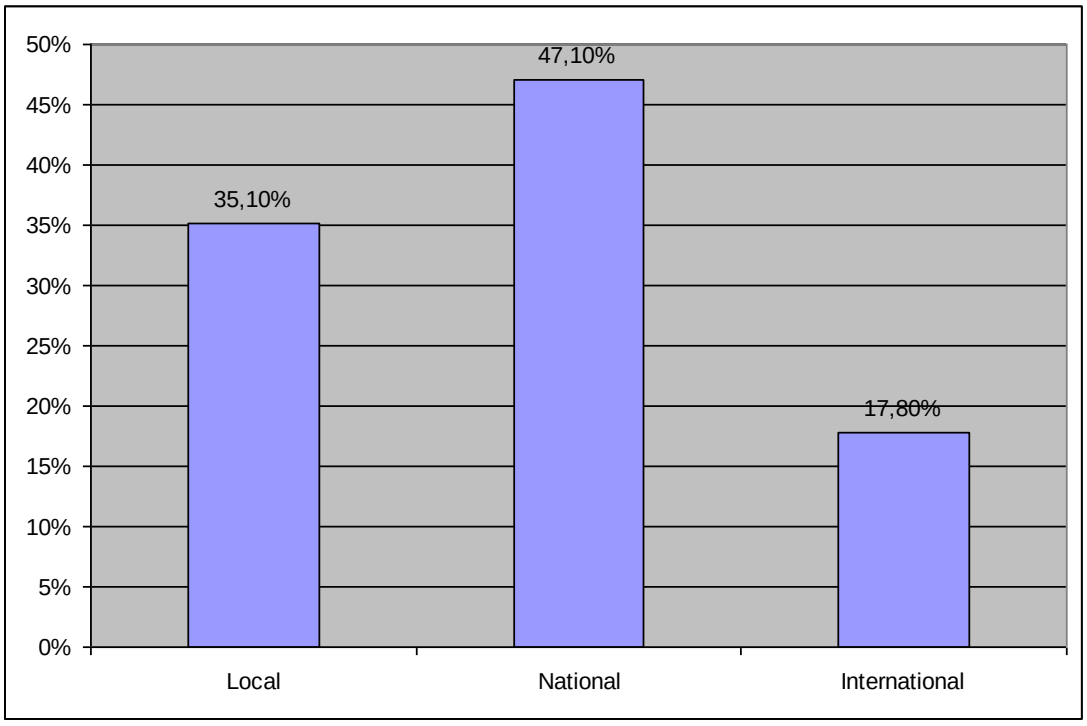

Figure 9. Employees' job location

As seen in Figure 10, the participating entities evaluate their staff's experience level, in a question with 33 responses. The answers show that 56,6% of employees are evaluated as high experienced, 24,7% as medium experienced level and 18,7% as low experienced.

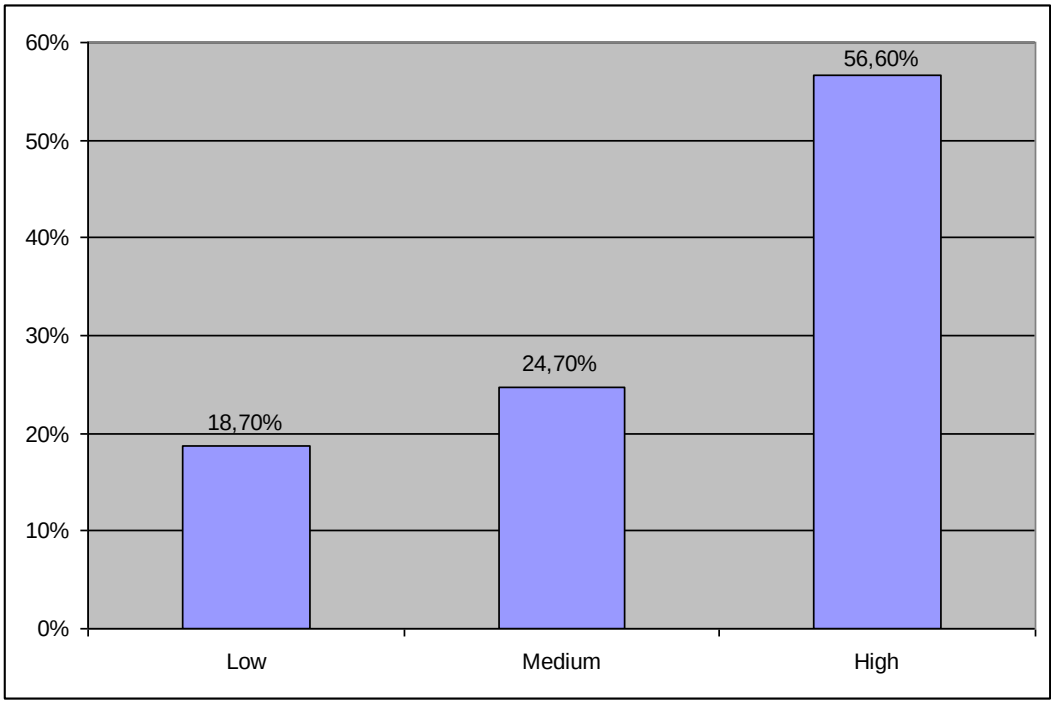

Figure 10. Employees' experience level

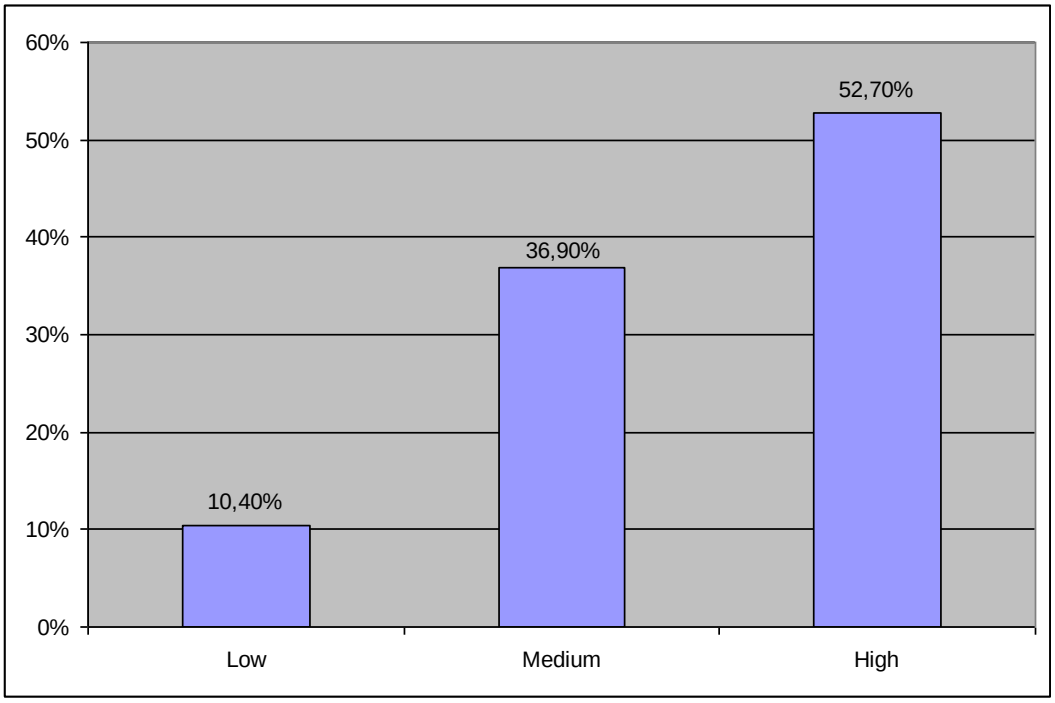

Figure 11. Employees' skills specialization

To conclude with the employees' characteristics, and to regard to their skills specialization, it is indicated that according to the participating entities 52,7% of the employees have high skills specialization, 36,9% medium and 10,4% low skills specialization. Thirty participants responded to this question, with the results presented in Figure 11.

The participating entities were also asked about the most important professions for the geothermal activities of their company / organization. Table 11 presents the most significant professions, based on the answers of 40 participants in an open-ended question. The professions that are considered most important are geologists and engineers, with a wide range of specializations involved, while the respondents also consider as important professions for their activities geophysicists, geochemists, technicians, maintainers and drilling consultants. Apart from the professions directly related to the geothermal activities of the companies/organizations, professions such as economic analyst, communications expert, IT expert and accountant are also considered as highly significant by the respondents.

Table 11. Most important professions in respect to the companies/ organizations geothermal activities

Profession	Specialization
Geologist	hydrogeology, mineral resources, geothermic, hydrocarbon, petrology, reservoir design, resource identification
Engineer	electrical, reservoir, industrial, mining, geologist, energy, drilling, civil, hydraulic, environmental, mechanical, thermal, structural, process, energy, software, well
Geophysicist	
Geochemist	
Drilling consultant	experience with operation of drilling rigs
Well service operator	
Technician	
Maintainer	
Electrician	
Manager	general, sales, project, marketing
Economic analyst	feasibility studies, investments assessment, financing possibilities, investor relations
Communication expert	communication with governmental authorities, wider public
IT expert	
Accountant	

Regarding the kind of activities that the companies/organizations subcontract and are related to the geothermal sector, 41,3% (19) answered that subcontracts drilling activities, while 39,13% (18) subcontracts consulting services on subjects like geochemical and geophysical surveys, plant designing, operation of drilling activities, feasibility and environment studies and local consultancy within relevant sectors. Subcontracted activities with a high response rate are equipment supply with 32,61% (15), research and development with 28,26% (13) and construction/manufacturing of power plant with 26,09% (12). In addition to the other activities that are subcontracted by the participating entities and are presented in Figure 12 (the question was answered by 46 participants), 17,39% (8) of answered they subcontract "other" activities, including geophysical data processing, geological plowing, as well as legal, financial, testing, training, supervision and certification services.

The participants were also asked to estimate the equivalent amount of jobs of the above subcontracted activities for the year 2011. This question was answered by 22 participants, and based on their responses, the mean value of equivalent jobs is 12,2 and the median value is 5. Using the median values, it is indicated that in activities related to geothermal sector, apart from the 6 individuals (has been estimated above) that each company/organization employees, 5 more individuals are occupied through subcontracting.

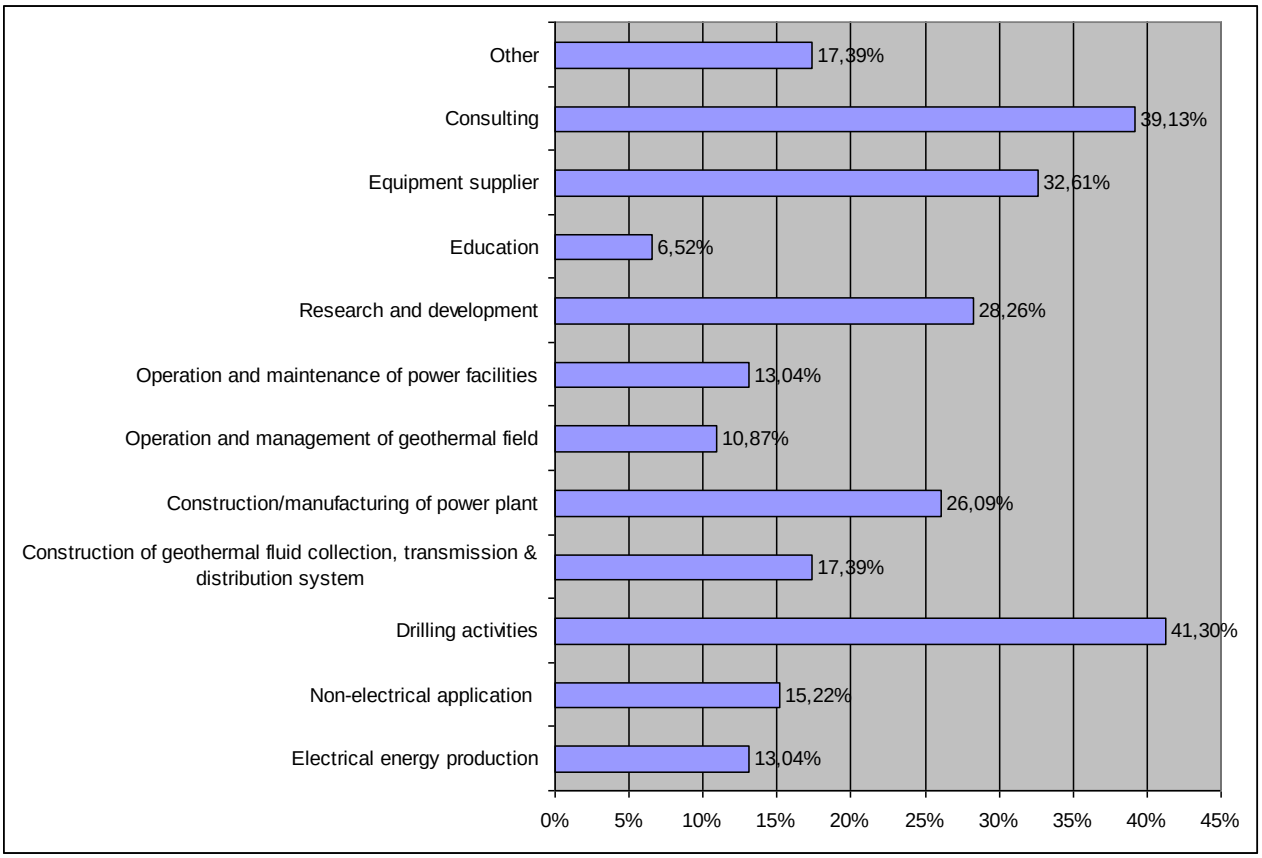

Figure 12 Activities related to the geothermal sector that companies/ organizations subcontract

Employment perceptions and qualities

The companies/organizations were questioned about their perceptions regarding employment in the geothermal sector during the next years (Figure 13), as well as their perceptions regarding their own financial status and employment (Figure 14). These 5 questions were answered by 36 participants. As presented in Figure 13, the entities agree and strongly agree that employment in the geothermal sector will be higher in 5 years, 10 years and 20 years from now, with the percentages of those who agree and strongly agree being 86,11% (31), 97,22% (35) and 94,45% (34) for each question respectively. It is also indicated that the longer in the future we go, the proportion of those strongly agreeing that employment in the geothermal sector will be higher increases, with the percentages for 5, 10 and 20 years being 27,78% (10), 44.44% (16) and 63,89% (23) respectively.

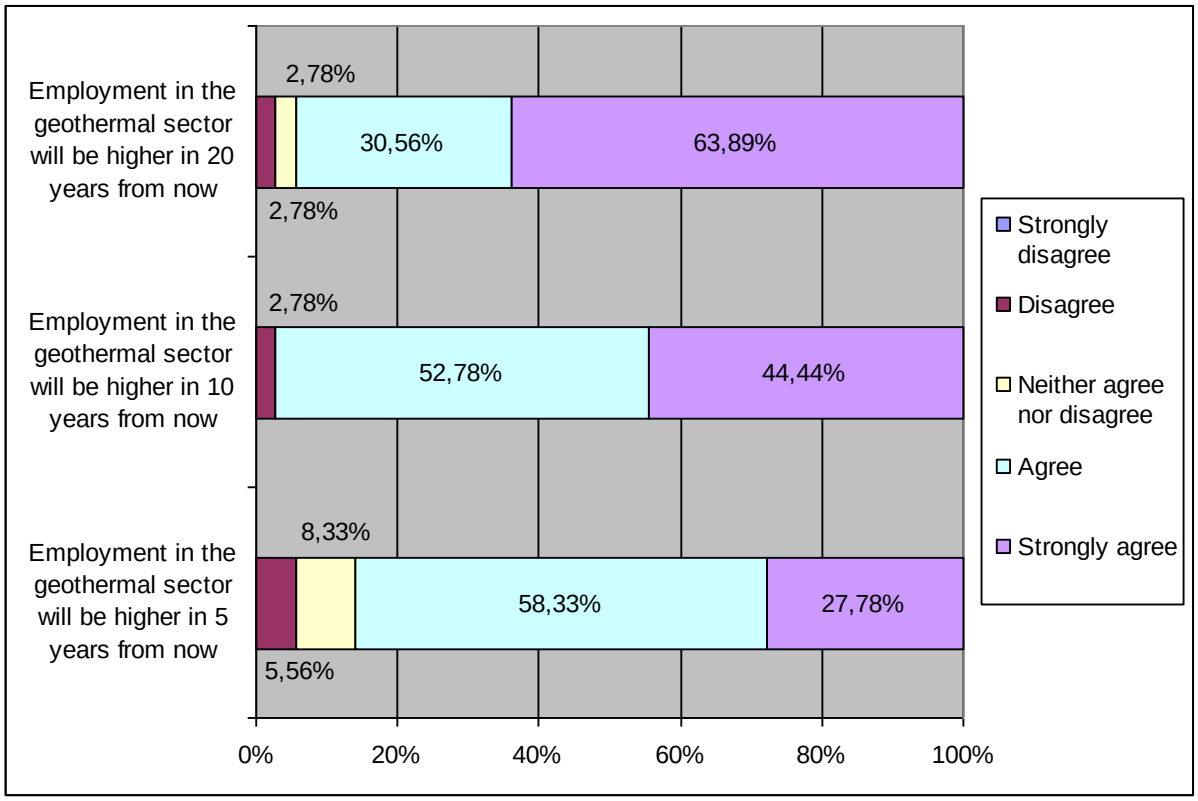

Figure 13. Employment perceptions

Through Figure 14 the perceptions that the participating entities have for themselves in 10 years from now are depicted. The participants seem to have positive perceptions, regarding both their financial expansion and the number of their employees, as in both questions most of them agree with the percentages being 41,67% (15) and 47,22 % (17) respectively for each question. Comparing the results of the question about whether the companies/organizations believe that they will employ more staff in 10 years from now and the question on the overall increase of employment in the industry in 10 years from now (Figure 13), it is indicated that the entities have more positive perceptions regarding the increase of employment in the sector, in relation to the perceptions they have about employment in their own company/organization. This becomes clear through the responses, as regarding the employment throughout the industry in 10 years, the positive (agree - strongly agree) perceptions are 97,22% (35), while the positive perceptions regarding employment increase in each one's company/organization is significantly lower, with 66,67% (24).

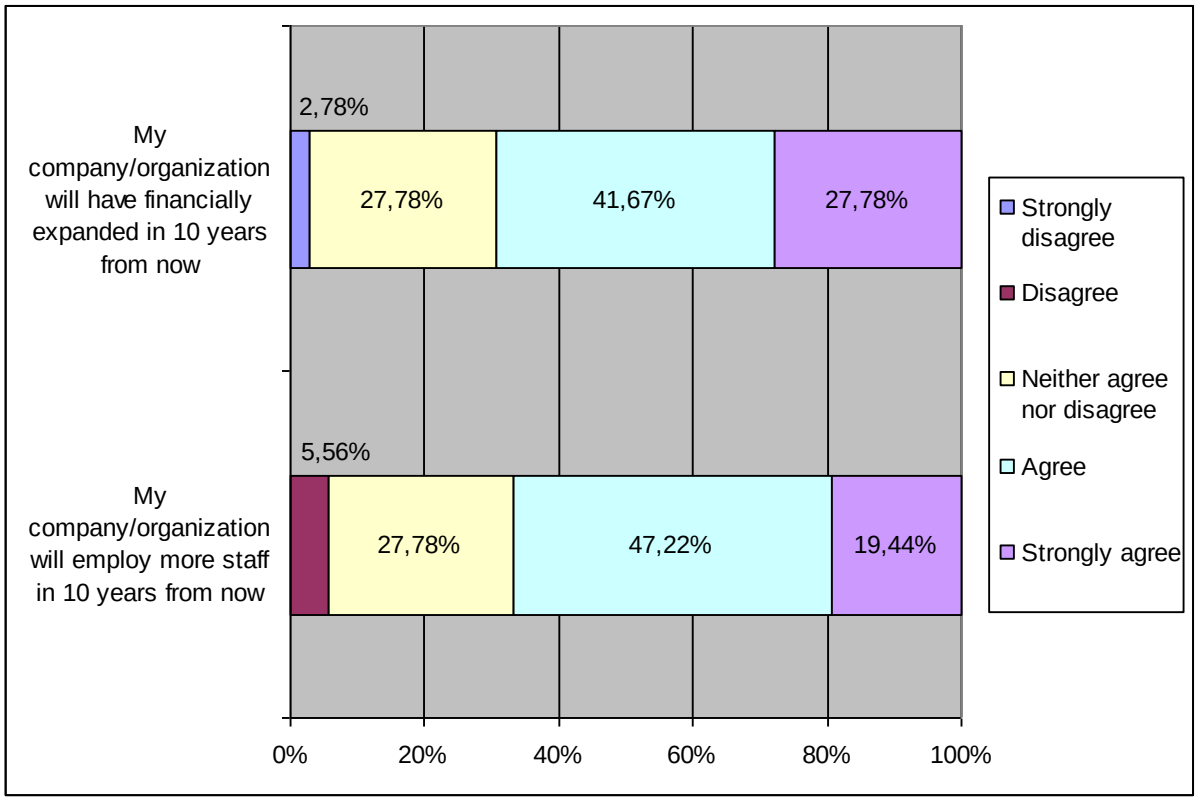

Figure 14. Company/ organization perception for 10 years from now

The participating entities were asked to estimate the percentage of the change of their company's / organization's staff number in 10 years, regarding today's numbers, defining at the same time if the change is positive or negative. Through 33 responses, it is reported that 72,73% (24) of the participants believe that in 10 years their staff will have increased, 21,21% (7) that the staff number will remain the same, 3,03% (1) that the staff number will be reduced, while 3,03% (1) answered that can not make an estimate (Figure 15). Regarding the percentage that the entities estimate that their staff number will change, through 31 responses it is calculated that the number of employees will have increased in 10 years from now by an average of 162.5% and median value of 70%.

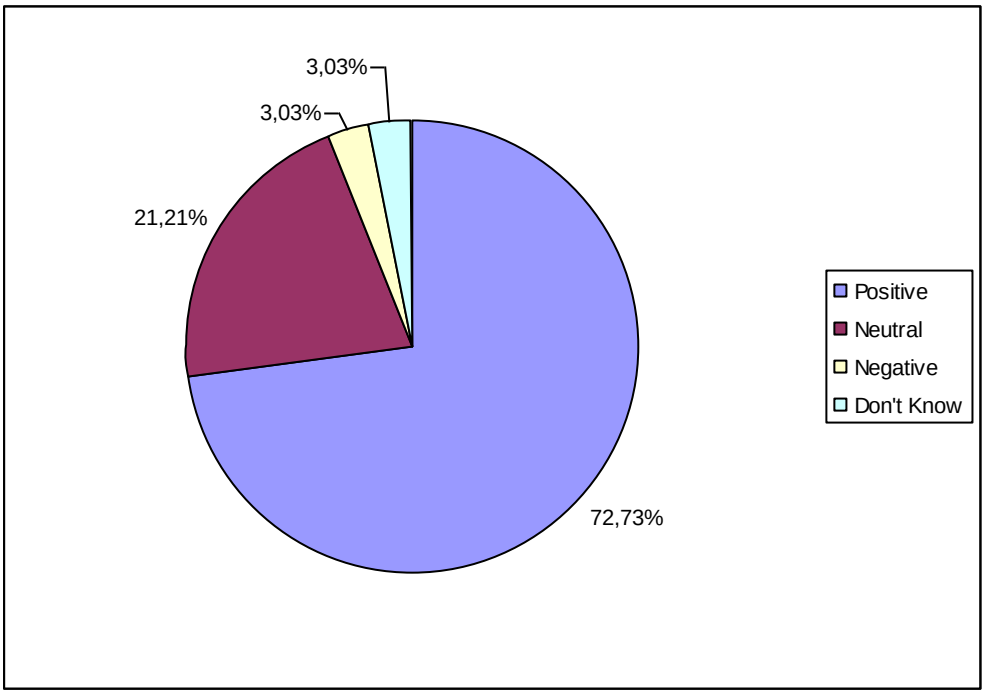

Figure 15. Perceptions regarding staff number in 10 years from now

The participants also make an estimate on the percentile change of their company's/organization's financial condition in 10 years, regarding today's levels. The 33 responses show that 66,67% (22) of the entities consider that the financial condition in 10 years will be improved, 18,18% (6) that there will be no change, 6,06% (2) that the financial condition in 10 years will be worse than today, while 9,09% (3) can not make such an estimate (Figure 16). Regarding the value of the percentile change of the financial condition in 10 years, through 27 responses an average change of 177,7% (medium: 100%) is calculated.

Comparing these results with the estimates on the change in employment in 10 years, it is indicated that although the general considerations on employment are positive in relation to the companies'/organizations' financial situation, when we examine the estimated percentile changes, it is detected that the percentile change of the financial condition is higher than the percentile change of the number of employees.

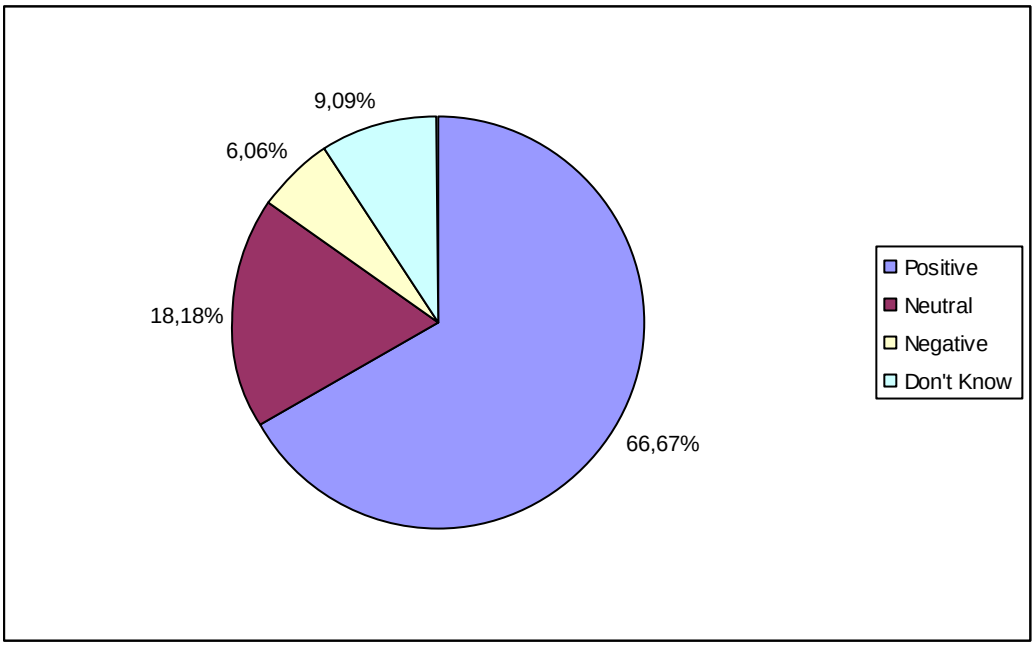

Figure 16. Perceptions regarding financial condition in 10 years from now

The views of the participants on skilled scientists, researchers and workers of the geothermal sector are presented in Figure 17, through 6 questions answered by 36 entities. It is found that the majority of the companies/organizations (77,78 % - 28) agree or strongly agree that demand for high skilled workers in the geothermal sector is raising. Also, there is an agreement on the fact that the geothermal sector is suffering from a lack of skilled workers and that the geothermal sector is suffering from a lack of skilled scientists and researchers, as the percentages of those who agree or strongly agree with the two above sentences are 75% (27) and 77,78% (28) respectively. Although the majority agrees that the geothermal sector suffers from skilled scientists, researchers and workers, the percentages of those believing that the lack of skilled scientists, researchers and workers creates a barrier to their company's/organization's operation are not accordingly high. Regarding whether the lack of skilled workers creates barriers, 34,28% (12) agrees or strongly agrees, 34,29% (12) has a neutral view, while 31,43% (11) disagrees with the fact that the lack of skilled workers creates barriers in their business's activities. The lack of skilled scientists and researchers affects the activities of the 30,55 % (11) of the respondents, while 44,44% (16) declared neutral and 25 % (9) negative into such a proposition. Also, the percentage of those believing that a transfer from another sector to geothermal requires a big amount of retraining is fairly high, with 61,11% agreeing or strongly agreeing with this sentence,

16,67% having a neutral view and 22,22% disagreeing with the fact that a big amount of retraining is required.

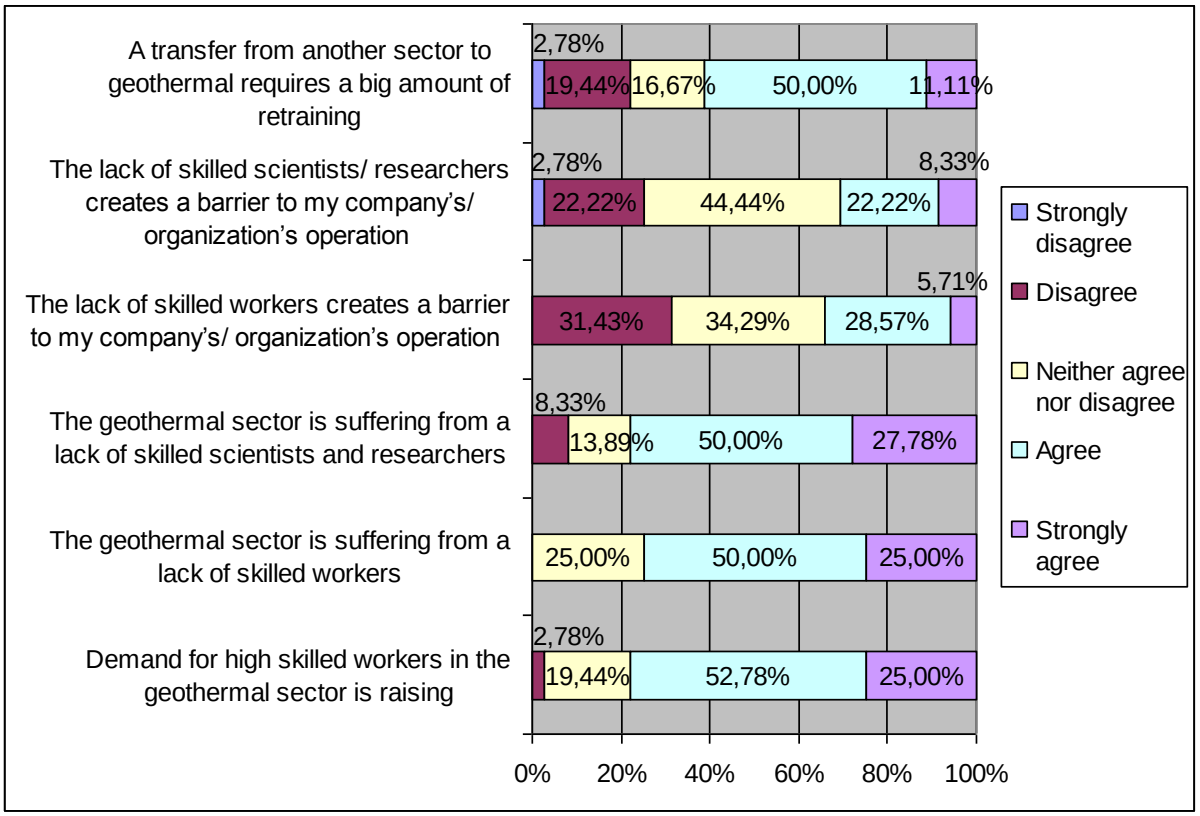

Figure 17. Views on lack of skilled workers, scientists and researchers in the geothermal sector

The participants were also questioned about their perceptions on what will happen in the next 10 years, referring to the skills needed in the geothermal sector professions, with 35 entities responding to each of the questions. As seen in Figure 18, the majority of the companies/organizations agrees or strongly agrees with the majority of the sentences. Specifically, 91,43% (32) agree or strongly agree that new skill requirements will increase, 94,29% (33) that higher level of skills will be required, 88,57% (31) that there will be need for multi-tasking and multi-skilling, 85,71% (30) that new and hybrid specialties will increase and 77,14% (27) that generic and social skills will be required.

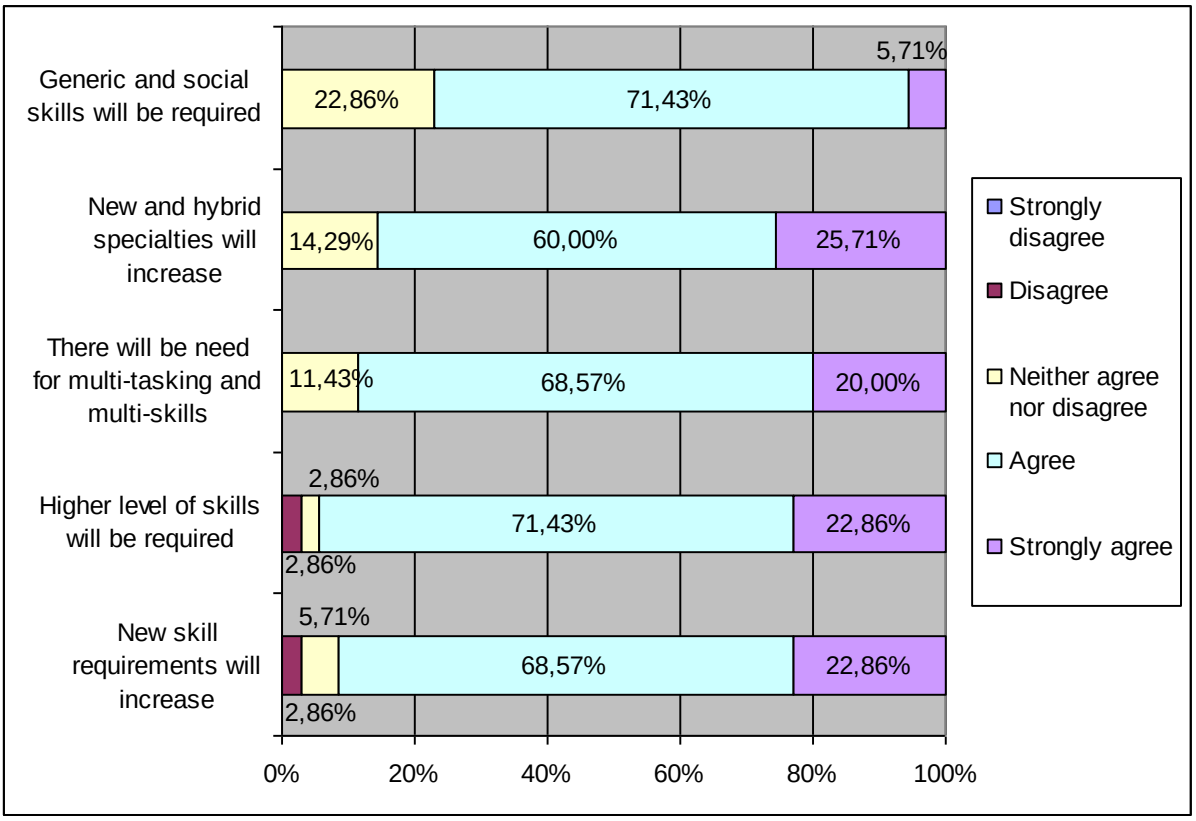

Figure 18. Perceptions on the skill needs of the geothermal sector in the next 10 years

Participants were asked about the professions directly related to their geothermal sector activities in which they encounter difficulties finding highly skilled personnel. The main specialties are presented in Table 12, in a question with 20 responses. The main professions in which difficulties finding highly skilled personnel are recorded are reservoir and geothermal engineers, as well as drilling consultants and equipment operators. Also, there is a difficulty in finding skilled personnel in specialized geologists, engineers of various specializations, power plant designers and managers, chemists and geoscientists.

Table 12. Professions directly related to the geothermal sector in which the companies/ organizations have difficulties finding highly skilled personnel

Profession	Specialization
Engineers	reservoir, geothermal, mechanical, energy systems, mining, geological, thermal
Drilling consultants and equipment operators	deep drilling, well stimulation, drilling rigs
Geologists	modeling, structural geology, exploration, geothermal energy
Power plant designers and managers	
Geoscientists	hydrogeology, geophysics
Chemists	scaling , corrosion, material science

Finally, the companies and organizations were questioned about the professions, directly related to geothermal sector activities, which they believe that will experience an increased demand in the future. The question had 25 responses and the results are presented in Table 13. The entities estimate that the professions that will show that the highest demand increase are drilling engineers and drilling equipment operators, specialized geologists, engineers of various specialties (mainly reservoir and geothermal), project and field managers, as well as installers and maintenance technicians.

Table 13. Professions directly related to the geothermal sector in which the companies/ organizations believe that there will be increased demand in the future

Profession	Specialization
Drilling engineers and drilling equipment operators	
Geologists	
Engineers	industrial, mining, energy, reservoir, environmental, mechanical, electrical, geothermal, thermal
Project and field managers	
Installers and maintenance technicians	
Project designers	
Geophysicists	
Chemist	material and corrosion
Financial and Information Technology professionals	
Hybrid specialists	
Quality control technicians	
Risk manager	insurance, environmental, social

6. ACTION PLAN

As it has been indicated by the results of the previous chapter, that employment in the geothermal power industry is expected to increase, while skill gaps and labour shortages may occur. It is very important to adopt policies and projects related to RES that will address the skill gaps and labour shortages issues. The potential of the geothermal power industry can be revealed only through the attraction, retention and renewal of the workforce talent. Companies and organizations need to adopt a range of measures which will allow them to have access to the highly skilled workforce they need.

A framework of actions is presented, so that possible skill gaps and labour shortages can be prevented and addressed. Of course, each country is unique with its own characteristics, its own weaknesses and opportunities, so it has to be treated differently.

Collaboration and coordination between stakeholders

In order to solve problems related to skill and workforce gaps, collaboration and coordination between involved stakeholders -such as employers, governments and education suppliers- is required, so that solutions to existing problems are given and future needs are planned. An important parameter that can affect significantly the success of the coordination process is the level of cooperation between private and public stakeholders, as well as the degree of each ones' participation.

Coordination between agencies should be developed regarding needs in education. Also, coordination is required between employers and professionals and technicians possessing the required skills, so that there can be a matching between skills supply and demand. Moreover, skill development policies and strategies should be coordinated and linked with industrial, technological, macroeconomic and environmental policies. Through coordination between stakeholders, available information can be disseminated easier and in a wider range.

Social dialogue

Social dialogue can play an important role regarding the identification of the skills required in the geothermal power industry, as well as to ensure that adequate education and training is being provided. Governments, employers, worker associations and education suppliers have a common interest in addressing skill gaps. That is why dialogue between social partners on identifying and addressing skill gaps is necessary in order to design and implement the best possible measures regarding skill development.

Educational and training programs concerning technicians or workforce newly entered to the industry can benefit from the social dialogue on a sectoral level. Also, social dialogue can benefit cooperation in educational issues between companies, universities, governments, so that activities will be better organized, more useful educational retraining programs will be created, and stronger links between the social partners will be created.

Stable investment steps

While planning the development projects regarding the geothermal power sector, particular attention should be given to a normal distribution of investment rates over time. This contributes in order to provide employment in a stable rate for the workforce, to avoid periods of large labour shortages for employers, and assist education and training suppliers to program their work. It is possible that this can not always be achieved. But whenever it is possible, a sudden demand for labour can be prevented, as it is usually followed by a respective decline. Also, this will assist to ensure that the demand of operation and maintenance workforce of a power plant will also remain stable during time.

Education

Enhancement of the educational and training process is the factor that can have the largest effect on the long-term needs regarding certain job specialties and skills. Ensuring the existence of necessary skills in the sector requires action at all levels of education and training, meaning technical and scientific education, training and continuous learning. In order to achieve the proper education reforms, cooperation between all organizations involved is required. Cooperation between companies, universities, polytechnic schools, training organizations, employment agencies and certification institutions is necessary. Cooperation between education and training institutes and companies is necessary, so that the number of graduates fits the requirements of the labour market, while students are

provided with the appropriate skills and knowledge. Linkage between universities and companies can also create a network which may allow a faster and more efficient treatment of the needs that are generated.

Education programs often cover basic skills, while they are not able to meet more specialized requirements. Developing the content of a course may require time, effort and expertise, factors that can limit the educational institutes. This may result to an unattractive educational or training program. This is why there must be cooperation, so that governments and geothermal power companies assist education suppliers to develop appropriate educational programs. Also, this cooperation will contribute to ensure a frequent updating of the content of educational and training programs, so that the skills and knowledge of graduates are always updated.

Financial support of both students and educational institutes is also a factor that can assist the whole process. In case the difficulty is in attracting young people, rather than the willingness of the industry to train them, then financial measures should aim more on the students. Financial incentives can be provided through covering the training cost of the students and by subsidizing educational and training programs.

University courses

Most jobs in the industry require a university degree. Existing university courses in fields such as engineering, bio-sciences, earth sciences, business administration and finance can provide the ground for working professionally in the industry. Many universities already develop their courses and curricula to address the growing interest in renewable energy generally and geothermal energy more specifically. Many universities also offer postgraduate studies specialized in these topics.

Apprenticeships, traineeship, cadetship

Apprenticeships, traineeships and cadetships can play an important role in the development of the appropriate skills. Hiring and training apprentices is a long-term solution in order to meet the needs regarding the availability of appropriate skills and workforce.

For some people, higher education courses are not the most appropriate way to develop high skills. An apprenticeship can offer a more practical and attractive way, especially for occupations which are necessary for the industry, as well as a satisfactory income.

Through these programs, the graduate or trainee can develop through internships the appropriate skills in real working conditions. An apprenticeship which includes both theoretical courses and training in real working conditions can develop individuals which will be able to work, providing a high level of skills in the field they have specialized.

Apprenticeships play a major role regarding the skills development of a sector, and this is why governments should actively support it. The existence of subsidies and other forms of support can assist employers to recruit and employ apprentices while they gain, useful for the company and the sector, skills.

Up-skilling and re-skilling through continuous education and training

Up-skilling and re-skilling of the staff through continuous education and training is important for industries where continuous development of technology occurs, for both technical and for scientific specialties, so that employees are capable to maintain their skills. There should be a long term investment in time and money, in order to improve the skills of the existing workforce, which is the most valuable asset of the industry.

Re-skilling can assist the existing workforce to fill the gaps that have been created, either in a specific specialty or a specific task, while it can also increase workforces' productivity regarding already existing tasks. Continuous education can be provided by companies, industry associations, trade associations, technology suppliers, universities and colleges, as well as by private education and training suppliers. Also, education inside the workspace, through online courses and other flexible options, can provide a good solution.

Apart from the knowledge and skills directly related to the job, continuous training is required in other essential skills such as communication and teamwork. Regarding the non-technical specialties (administration, finance, etc.), continuous updating of skills and knowledge concerning the geothermal power industry is required, so that the aforementioned workforce can respond to the industry's needs. Also, there is a need of a continuous updating with changes to environmental codes and regulations.

Advantages of up-skilling are higher standards of safety, higher productivity and employees feeling valued. It can also contribute to knowledge management, meaning to retain the accumulated knowledge, also known as corporate memory.

Retraining

It should be possible for workers from other sectors with similar skills who want to relocate in this sector and graduates of educational courses that have not acquired yet the appropriate expertise to be able to participate in retraining and additional training programs, in order to obtain the appropriate skills for electricity production using geothermal energy. Retraining can practically be the largest part of the training required by the sector, in order to have the necessary skills for the industry, as in many cases individuals who are interested in the industry are active in different, but related, fields.

Maintaining knowledge

It is important that every company of the geothermal power sector, as well as the whole industry in general, is able to maintain the accumulated knowledge and skills that have been acquired during the past. Companies may experience a loss of staff –and as a result the loss of knowledge- not only because of retirement, but also from loss of younger staff to competitors and other industrial sectors. In the cases that loss of experienced staff due to retirement is inevitable, developing programs that guarantee that the knowledge that a company obtains regarding its operation will not be lost is essential. That is why strategies of creation and maintenance of knowledge are required. Keeping older employees through strategies like phased or flexible retirement, part-time re-hiring options or mentoring programs, may be useful for this purpose.

Emphasis on transferred skills

Education and training programs targeting on the sector should focus on skills that can be transferred between different fields. Employment in the development, manufacture and installation can be unstable, even if attempts are made to obtain an approximate smooth transition. In occupations associated with the operation and maintenance, there may also be periods where the intention to recruit new trained workers will be limited. Education and training programs should therefore be developed around a core specialty which will be suitable for a wider range of sectors.

Standardization of educational and training programs

Skill requirements are relatively similar at national and regional level, regarding not only the geothermal power sector, but the entire RES sector. To have a common basis, international cooperation in order to standardize the requirement and skill standards of educational and training programs and their content is desirable. Transnational networks and initiatives make it easier for employers to understand the skills required by organizations in other countries, thus contributing to international mobility of employees.

These actions can also contribute to the reduction of the initial cost that an innovative educational or training program requires in order to start. Also, bilateral relations between companies and educational institutions can conduce to the establishment of an internationally recognized industry certification.

Increasing the number of trainers

The lack of suitable trainers is a factor that can create obstacles for employers and educational institutions, regarding the supply of educational and training programs, having as a result the institutions to be unable to meet the growing demand created for training and education on new skills and fields of study.

Because of the nature of the of geothermal projects, demand for workforce in the industry can increase relatively suddenly, while skill requirements are constantly changing because of technological change, forcing the educational and training institutes to bring together the specialized teaching staff in a rather short time.

Cooperation with institutes that are already experts/specialists in renewable energy education and training generally, and geothermal education specifically, mobility (exchanges) of staff and collaboration with the industry are practical ways to meet the created demand.

Encourage international cooperation between providers of education and training

The skill and workforce gap issue must be recognized and addressed, not individually, but comprehensively by all countries. International and intergovernmental organizations should work in order to promote cooperation between countries. This may include cooperation and measures to increase the mobility between educational and training suppliers, researchers and apprentices which are involved in the education and training process and in the development procedures of standards regarding skill qualifications in different countries.

Acquire and improve generic skills

In addition to the specific skills that someone should hold, generic skills are also required, in order to be able to meet the requirements of the geothermal industry and be able to get employed. The acquisition of generic skills is very important because it can provide flexibility and adaptability, which allows someone to deal with different activities and tasks within the company, and can help a person shift between different sectors and regions.

Regarding the geothermal power industry, generic skills consist of fundamental competencies in areas of science, as well as general skills such as information technology, foreign languages and awareness on environmental issues. Other useful skills are project management, installation and commissioning skills, techno-commercial marketing skills, teamwork, interpersonal communication, leadership and organization, presentation skills, learning ability etc. Companies often require not only theoretical and technical skills, but also skills such as flexibility, motivation, loyalty, dedication and self presentation.

The specific skills required for each working position should be acquired or improved through workshops and training programs provided by the company or the whole sector, in combination with governmental support whenever it is necessary. The educational and training programs of generic skills should follow the financial and legislative changes and should be flexible and adaptable, in order to remain effective and up to date.

Recording skill shortages

Shortages in high skill positions are difficult to be defined and measured. Ideally, the measurement of these shortages requires employers providing accurate data regarding the extent, the types and the periods of skill and workforce gaps.

Recording shortages can contribute to the prompt identification of future skill needs. In addition to the quantitative recording of shortages, it is important to also have a qualitative recording, in order to recognize skill gaps, shortage occupations and recruitment difficulties.

Next, the gaps identified can be addressed in a better manner, since stakeholders, such as companies, worker association representatives and education and training suppliers can make a better planning of the required actions, while it is important that the results of the measurements are widely disseminated.

The recording and forecasting of needs can ensure that policies and investments that will attract more young people in the geothermal power industry will be realized, while there will also be up-skilling of the existing staff through continuous training.

Improving the industry's profile

New young entrants are often poorly informed about opportunities, working conditions, job satisfaction, salaries and opportunities to learn new things regarding the geothermal power industry. The industry needs to improve its image, thus making itself more attractive for young new entrants. This can be achieved through various measures, such as raising awareness about the benefits of working in this industry, improving the provision of information on career opportunities, advice and guidance, encouraging existing employees to act as advertisers and spread out the benefits of working in this industry to possible new employees. Advertisement campaigns, workshops, presentations, career evenings and other actions can also contribute to wider dissemination of the above.

Improving employees' benefits and workplace environment

The deficiencies in skilled personnel will be easier addressed if the geothermal power industry can offer attractive salaries and working conditions, while creating adequate education programs and the opportunity for the workforce to acquire skills that can be used in case of shifting to another sector. Also, the provision of continuous education and training by the company is important, as well as the opportunity that an employee may have to develop within the company. These actions will not only assist the creation of a relationship of trust between the company and its staff, but will also help to attract talented young people from different levels of education.

Enhancing the working conditions quality

Policymakers and businesses should take into account the working conditions of the total workforce, both highly skilled and lower skilled professionals and workers. Wherever necessary, workforce should be allowed to organize and claim better conditions and a better working environment. Of course, companies can also contribute to the improvement of working conditions by realizing some of the suggestions mentioned above.

Absorbing workforce of declining industries

As the transition towards RES is progressing, it seems inevitable that significant reductions will occur in fossil fuel employment. Like every industry that is negatively touched by regional, national or European policies, it will be important to plan a fair transition for the workforce that has been affected. This implies that the general transition must occur with a stable pace, and not at once. It also implies that the workforce that has been affected has the opportunity to acquire new skill through retraining, so that they can get employed in the geothermal sector.

Attracting women into the sector

The proportion of women following education and training paths related to technical and engineering occupations is not very high. Skill and workforce shortages can be partly reduced if the geothermal power sector, as a relatively new and dynamic field, manages to overcome the traditional barriers that gender creates regarding segregation of working specialties, so that more women get actually involved in technical and engineering occupations. Of course, this will only be possible if the same educational and training opportunities are available for women, if women can overcome cultural and social barriers and whether the professional guidance and incentives (e.g. salary) are available in order to attract women in this kind of technical studies.

Mobility

Stimulating mobility of high-skilled employees between countries can contribute to the reduction of skill and workforce shortages. Regarding the mobility of employees within the EU members, movement is free as one of the fundamental freedoms of the Common Market. On the other hand, the immigration of individuals from third-countries (countries outside the EU) remains in the national policy context of each individual EU member.

Facilitating the mobility of high-skilled scientists and workers between the EU members will not only provide a solution to the geothermal power industry, but will also motivate the entire economy, while the European citizens will benefit from job opportunities in other EU countries. The mobility of high-skilled employees has been enhanced by EU through educational policies, namely the harmonization of educational programs and the mutual recognition of university diplomas. Mobility between EU members can be facilitated by actions that have been mentioned above, as standardization of educational and training programs, standardization of needed skills, recording skill shortages, as well as providing a

specific framework of working conditions for employees and apprentices. Also, the existence of specialized employment agencies, and an online portal that provides information on employment and education opportunities on the geothermal power sector across the EU can assist the process and support mobility.

Apart from the mobility between the EU members, highly skilled scientists and workers can be attracted from third-countries. The European Commission has introduced the EU blue card initiative, which is a temporary work permit and gives a common policy basis regarding skilled immigration for all EU countries. In order to gain this license certain criteria must be met from the side of the employee, such as existence of a work contract, professional qualifications and a salary above national minimum level. Although EU initiatives have increased during the recent years in terms of immigration policy, key decisions are still taken at national level by the governments. The position of the EU as a significant player of the international labour market can strengthen through the harmonization of the local policies across Europe, in order to create a common framework and the application of the suitable institutional settings for European companies.

The governments can play a positive or negative role in attracting highly skilled employees by facilitating the issuing of work permits, tax incentives, and by promoting the country as an attractive destination to live and work. Also, the governments can assist the companies on locating highly skilled employees from abroad, by adopting the appropriate policy framework.

The use of workforce from third-countries does not imply loss of jobs for the local population. On the contrary, according to the neoclassical approach, attracting foreign skilled labour can contribute to global economic development. It can contribute positively to the economic activity of some sectors, which can lead to the creation of new job positions, thus benefiting the entire economy and society.

Besides, the international movement of people with high skills is a significant mean through which knowledge, skills and other abilities can be transferred. Host countries benefit from the presence of foreign employees through knowledge and expertise transfer. At the same time, the countries of origin of the employees can benefit if these people keep in touch with their country through professional networks, exchange programs, and with the return of the

person to his country of origin, thus transferring all the extra expertise and knowledge acquired.

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APPENDIX

QUESTIONNAIRE:

Employment in geothermal electricity sector

The GEOELEC project (http://www.geoelec.eu/) is a pan-European project on geothermal electricity, supported by the Intelligent Energy Europe programme of the EU. The objective of the GEOELEC project is to convince decision-makers about the potential of geothermal electricity in Europe, to stimulate banks and investors in financing geothermal power projects and finally, to attract key potential investors such as oil and gas companies and electrical utilities to invest in geothermal power.
This questionnaire aims to collect current data regarding present and future employment needs, job qualifications and re-specialization needs in the geothermal electricity sector.

I. COMPANY/ORGANIZATION INFORMATION

1. Name of company/organization……..	
2. Legal entity of company/organization.....	

3. Contact information (so that double counting of companies/organizations is avoided - all information provided will be kept confidential):

First name....	
Last name….	
Title……..	
Email……	

4. In which country is your company/organization based?	
5. In which other countries is it mainly activated?.....	

6. Is your company/organization also activated outside the geothermal sector? (circle)……..
Yes No

If yes, what percentage of your activities does geothermal energy represent?..... | |

7. Does your company/organization own other companies/organizations involved in the geothermal sector? (circle)…… Yes No

If yes, record the companies/organizations that your company/organization owns, whose data will also be included when you respond to the remaining questions of the questionnaire:

8. Does your company own geothermal power plants?(circle)…….. Yes No

If yes, what is the total installed net capacity of these power plants?..... | | (MW)

[1] ***Privacy information*****:** we guarantee that the processing of personal data received in this questionnaire is in accordance with the regulations on the confidentiality of the information and it will be used exclusively for the elaboration of internal statistics to the project. In no case, your data will be used for purposes different than those determined in the GEOELEC project. If you have any concerns or questions, please contact us at: spkary@cres.gr

9. Please check the types of business your organization/company is involved in:

Electrical energy production……..	
Non-electrical application …….	
Drilling activities……	
Construction of geothermal fluid collection, transmission & distribution system…...	
Construction/manufacturing of power plant……	
Operation and management of geothermal field……	
Operation and maintenance of power facilities……..	
Research and development (please define)……..	
Education……	
Equipment supplier……..	
Consulting (please define)……..	
Other (please define)……..	

II. EMPLOYMENT IN YOUR COMPANY/ORGANIZATION

Please consider only employees working directly for your company/organization (not contractors and consultants). The following questions refer to the year 2011.

1. How many people does your company/organization employ? (all activities)……..	
2. How many of them work in activities related to the geothermal sector?.....	

3. How many of them are:

full-time employees……..	
part-time employees……..	

4. In what percentage are the employees of your company/organization represented in the following categories (not contractors and consultants):

	Local	National	International
a. Employees' job location			

	Low	Medium	High
b. Employees' experience level			
c. Employees' skills specialization			

5. Which are the most important professions for your company/organization geothermal

activities?

	Profession	Specialization
a.		
b.		
c.		
d.		
e.		
f.		
g.		
h.		

6. Choose the kind of activities your company/ organization subcontracts and are related to the geothermal sector:

Electrical energy production……..	
Non-electrical application …….	
Drilling activities……	
Construction of geothermal fluid collection, transmission & distribution system…...	
Construction/manufacturing of power plant……	
Operation and management of geothermal field……	
Operation and maintenance of power facilities……..	
Research and development (please define)……..	
Education……	
Equipment supplier……..	
Consulting (please define)……..	
Other (please define)……..	

7. Please estimate the equivalent amount of jobs of the above subcontracted activities:
[ ] (in year 2011)

III. EMPLOYMENT PERCEPTIONS AND QUALITIES

1. State your level of agreement with the following arguments:

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Employment in the geothermal sector will be higher in 5 years from now					
Employment in the geothermal sector will be higher in 10 years from now					
Employment in the geothermal sector will be higher in 20 years from now					
My company/organization will employ more staff in 10 years from now					

My company/organization will have financially expanded in 10 years from now					

2. What will be the percentage of the change of your company's/organization's staff number in 10 years, regarding today's numbers? (define if change is +/-).....

3. What will be the percentage of the change of your company's/organization's financial condition in 10 years, regarding today's numbers? (define if change is +/-)…….

4. State your level of agreement with the following arguments:

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Demand for high skilled workers in the geothermal sector is raising					
The geothermal sector is suffering from a lack of skilled workers					
The geothermal sector is suffering from a lack of skilled scientists and researchers					
The lack of skilled workers creates a barrier to my company's/ organization's operation					
The lack of skilled scientists/ researchers creates a barrier to my company's/ organization's operation					
A transfer from another sector to geothermal requires a big amount of retraining					

5. Referring to the skills needed in the geothermal sector professions, on what level do you agree that the following will happen in the next 10 years?

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
New skill requirements will increase					
Higher level of skills will be required					
There will be need for multi-tasking and multi-skills					
New and hybrid specialties will increase					
Generic and social skills will be required					

6. In which professions directly related to geothermal sector activities your company/organization has difficulties finding highly skilled personnel? Please report the

most significant for your company/organization activities:

	Profession	Specialization
a.		
b.		
c.		
d.		
e.		

7. In which professions, directly related to geothermal sector activities, do you believe that there will be increased demand in the future? Please report the most significant for your company/organization activities:

	Profession	Specialization
a.		
b.		
c.		
d.		
e.		

Thank you for your help