Co-funded by the Erasmus+ Programme of the European Union

COMPETENCE MATRIX

Summary report – Intellectual Output 1

1 INTRODUCTION

The objective of the competence matrix and the Geo3En project, is to make a proposal to the stakeholders of the geothermal industry and to define what students need to learn to become the engineer that the industry is looking for.

The stakeholders' panel reflects the diversity of scientific culture and professional background of the geothermal science and technology market branch, from research and exploration of the resource, benchmarks, and financial analysis of the economics of geothermal prospects and plays, up to downstream activities, with power plants design, installation, operation, and maintenance.

This market study of the skill needs of the leading employers has two major advantages, 1- better insertion of future graduates in the labor market, 2- economic development of the projects strengthened because the availability of qualified and quasi-operational and self-sufficient collaborators at the end of the master, thus less need for time and investment of basic and general training by the stakeholders.

The design of these engineering degrees with a comprehensive knowledge of techniques and practices in the geothermal sciences was partly based on collaboration between the different institutes and by taking up the main lines of the results of the MEET project on the transdisciplinary aspects.

The competence matrix analyzed here will help to define the professional outlet of the Geo3EN graduates.

2 COMPETENCE MATRIX RESULTS

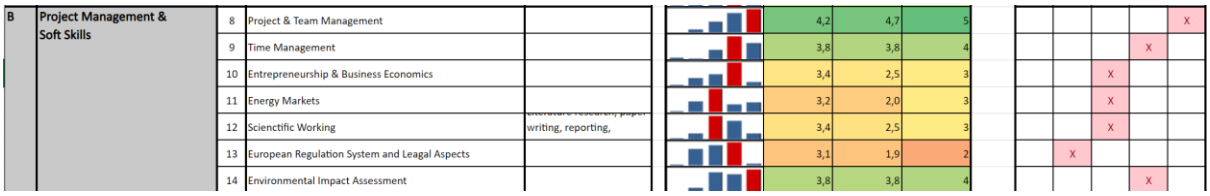
This first category of competencies essential (Figure 1) for any scientist involved in geothermal science and engineering consists of the fundamentals of hard sciences (Mathematics, physics, chemistry, and electrical engineering). According to the rating questionnaire, the stakeholders rate fluid dynamics and heat transfer as the most important competence of this panel, followed by Mathematics, physics, and technical thermodynamics. The dynamics and heat transfer skill requires a strong basis in mathematics, physics, and thermodynamics. Electrical engineering and inorganic chemistry appear less critical and can be developed in advanced courses.

Cat.	Main categories	No.	Competencies	Specifications	Rating questionaire				Rating				
					Histo	AVG	Scaled	Rnd	Not important 1	2	3	4	Important 5
A	Mathematical-Scientific Fundamentals	1	Mathematics	fundamentals		3,4	2,7	3			X		
		2	Geostatistics & Regionalization			3,2	1,9	2		X			
		3	Physics	fundamentals		3,4	2,7	3			X		
		4	Technical Thermodynamics,			3,4	2,6	3			X		
		5	Inorganic Chemistry	fundamentals		2,5	0,0	1	X				
		6	Electrical Enginerring	fundamentals		2,6	0,3	1	X				
		7	Fluid Dynamics and Heat Transfer	fundamentals		3,8	3,6	4				X	

Figure 1: Matrix for corpus A relative to scientific fundamentals, including mathematics and physics.

Another set of skills essential for future scientists and engineers is related to the soft skills acquired during the program (Figure 2). This whole corpus has been granted one of the highest-ranking with several grades above 4/5. This specifically concerns the project management aspects and methodologies. Stakeholders consider as essential that future employees master project and team

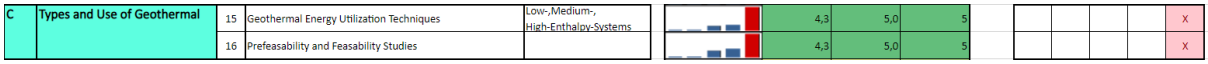
management and time management. Environmental impact assessment is regarded as necessary for administrative and technical aspects, followed by entrepreneurship and business economics, scientific working, notions on energy markets, and regulatory aspects at the European level.



B	Project Management & Soft Skills	8	Project & Team Management		4,2	4,7	5							X
		9	Time Management		3,8	3,8	4						X	
		10	Entrepreneurship & Business Economics		3,4	2,5	3				X			
		11	Energy Markets		3,2	2,0	3				X			
		12	Scienctific Working	writing, reporting,	3,4	2,5	3				X			
		13	European Regulation System and Leagal Aspects		3,1	1,9	2			X				
		14	Environmental Impact Assessment		3,8	3,8	4						X	

Figure 2: Matrix for corpus B relative to project management and soft skills

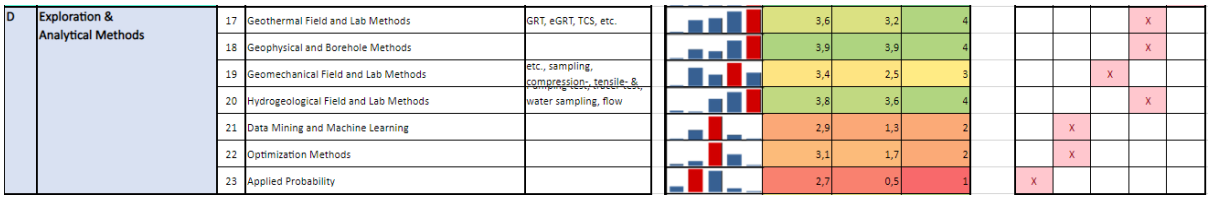
The third corpus (Figure 3), dealing with the application and type of geothermal energies and technologies, is regarded as crucial by the stakeholders, with a rank of 5/5.



C	Types and Use of Geothermal	15	Geothermal Energy Utilization Techniques	Low-,Medium-, High-Enthalpy-Systems	4,3	5,0	5							X
		16	Prefeasability and Feasability Studies		4,3	5,0	5							X

Figure 3: Matrix for corpus C relative to geothermal feasibility and utilization techniques

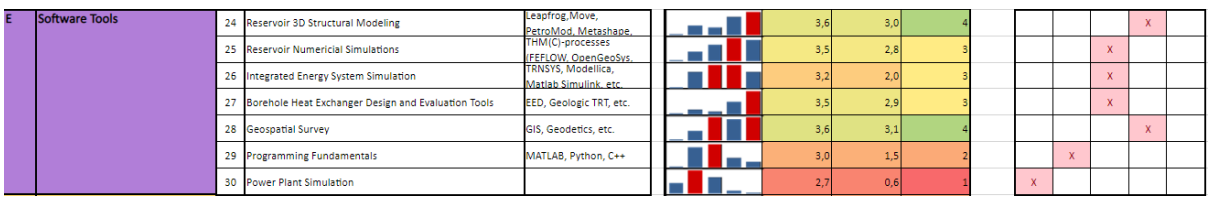
For this fourth corpus (Figure 4), the ranking by stakeholders is heterogeneous. The stakeholders regarded some aspects of skills regarding the geothermal, geomechanical and hydrogeological field and lab methods as necessary, with ranking above 3/5. Other types, involving data mining, machine learning, probabilities and optimisation methods are regarded with minor importance, with ranking below 2.5/5.



D	Exploration & Analytical Methods	17	Geothermal Field and Lab Methods	GRT, eGRT, TCS, etc.	3,6	3,2	4						X	
		18	Geophysical and Borehole Methods		3,9	3,9	4						X	
		19	Geomechanical Field and Lab Methods	etc., sampling, compression-, tensile- &	3,4	2,5	3				X			
		20	Hydrogeological Field and Lab Methods	water sampling, flow	3,8	3,6	4						X	
		21	Data Mining and Machine Learning		2,9	1,3	2			X				
		22	Optimization Methods		3,1	1,7	2			X				
		23	Applied Probability		2,7	0,5	1	X						

Figure 4: Matrix for corpus D relative to exploration and analytical methods

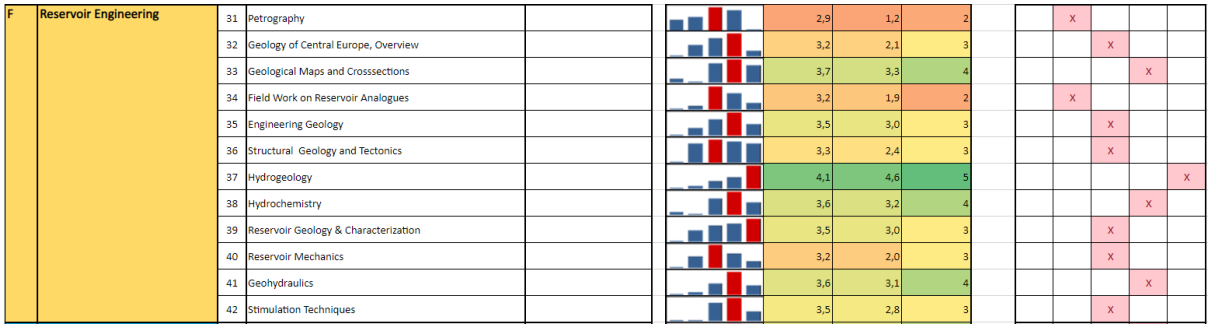
Similar to the various items presented in the corpus D, the stakeholders do not consider the diversity of software tools(5th Corpus E) with the same degree of importance (Figure 5). Main interests concern the 3D reservoir and structural modeling, associated numerical simulations, the capacities to perform geospatial surveys and create and simulate integrated energy systems, particularly involving the design of borehole heat exchangers and evaluation. This last point can be explained by the versatility and the wide range of potential applications and implementation of such technology, thus of the fast market upscale and business interests private and industrial stakeholders show towards these skills.



E	Software Tools	24	Reservoir 3D Structural Modeling	Leapfrog,Move, PetroMod, Metashape,	3,6	3,0	4						X	
		25	Reservoir Numericial Simulations	THM(C)-processes (FEFLOW, OpenGeoSys,	3,5	2,8	3				X			
		26	Integrated Energy System Simulation	TRNSYS, Modellica, Matlab Simulink, etc.	3,2	2,0	3				X			
		27	Borehole Heat Exchanger Design and Evaluation Tools	EED, Geologic TRT, etc.	3,5	2,9	3				X			
		28	Geospatial Survey	GIS, Geodetics, etc.	3,6	3,1	4						X	
		29	Programming Fundamentals	MATLAB, Python, C++	3,0	1,5	2			X				
		30	Power Plant Simulation		2,7	0,6	1	X						

Figure 5: Matrix for corpus E relative to software tools

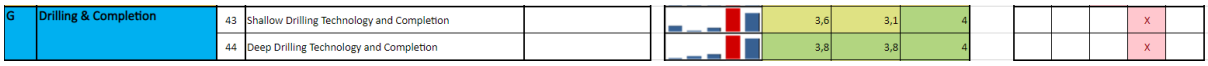
The 6th corpus F (Figure 6) focuses on reservoir engineering and comprises eleven sub-competencies that have various ranking of importance for the stakeholders. The most important skill is hydrogeology, followed by geological mapping and cross-section building, e.g., reconstructing the subsurface architecture conceptually from field observations, followed by hydrochemistry and geohydraulics. Petrography and reservoir geomechanics are regarded as less crucial, as these skills also can be developed in a more senior level.



F	Reservoir Engineering	31	Petrography		2,9	1,2	2		x				
		32	Geology of Central Europe, Overview		3,2	2,1	3			x			
		33	Geological Maps and Crosssections		3,7	3,3	4				x		
		34	Field Work on Reservoir Analogues		3,2	1,9	2		x				
		35	Engineering Geology		3,5	3,0	3			x			
		36	Structural Geology and Tectonics		3,3	2,4	3			x			
		37	Hydrogeology		4,1	4,6	5					x	
		38	Hydrochemistry		3,6	3,2	4				x		
		39	Reservoir Geology & Characterization		3,5	3,0	3			x			
		40	Reservoir Mechanics		3,2	2,0	3			x			
		41	Geohydraulics		3,6	3,1	4				x		
		42	Stimulation Techniques		3,5	2,8	3			x			

Figure 6: Matrix for corpus F relative to reservoir engineering.

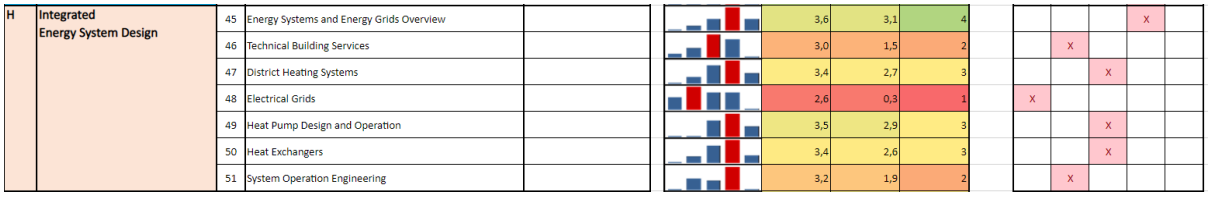
The seventh corpus investigated by the competencies matrix focuses on drilling and completion thematics (Corpus G, Figure 7), which are essential, ranking above 3.5/5.



G	Drilling & Completion	43	Shallow Drilling Technology and Completion		3,6	3,1	4					x	
		44	Deep Drilling Technology and Completion		3,8	3,8	4					x	

Figure 7: Matrix for corpus G relative to drilling and completion.

The 8th corpus H (Figure 8) contains all the competencies related to integrated energy system design. The interest of stakeholders in these competencies is variable. The overview of energy systems and energy grids has the highest rank, suggesting that stakeholders wish to have collaborators able to have an overview of the global approach. The lower ranking for the detailed itemization of each element of the energy system, though, translates that it is not essential for stakeholders that future professionals are experts in each specific thematics. Specialization in such items will be regarded as a bonus naturally, but not an essential component of the core basis every professional needs.



H	Integrated Energy System Design	45	Energy Systems and Energy Grids Overview		3,6	3,1	4					x	
		46	Technical Building Services		3,0	1,5	2		x				
		47	District Heating Systems		3,4	2,7	3			x			
		48	Electrical Grids		2,6	0,3	1	x					
		49	Heat Pump Design and Operation		3,5	2,9	3			x			
		50	Heat Exchangers		3,4	2,6	3			x			
		51	System Operation Engineering		3,2	1,9	2		x				

Figure 8: Matrix for corpus H relative to integrated energy system design

The same observations and headlines (Figure 9) can be extracted from the analysis of the results of the evaluation of the 9th corpus I of the competencies matrix, with majors in power and heat plant design and operation. A global and general overview is considered essential (ranking of item 52 on geothermal power plant types at 3.5/5). However, specification in power plant operation and management is ranked lower, suggesting the lesser crucial character of such skill for stakeholders.

I	Power & Heat Plant Design and Operation	52	Geothermal Power Plant Types		3,5	2,9	3			x		
		53	Geothermal Power Plant Components		3,3	2,3	3			x		
		54	Cogeneration of Heat and Power		3,2	2,0	2		x			
		55	Power Plant O&M		2,9	1,1	2		x			
		56	Corrosion and Scaling		3,3	2,3	3			x		

Figure 9: Matrix for corpus I relative to power and heat plant design and operation.

3 CONCLUSIONS

To summarise the main lines of the analysis of this matrix, future graduates will have to master the following skills:

- On the scientific and technical aspects, have knowledge of the whole chain of research, exploration, development of geothermal reservoirs including in particular:
  - Geology, production techniques and how to sell it
  - Exploration, consulting and geo-consulting (geothermal site detection, exploration methods, field, geophysics, physical laboratory measurements, etc.)
  - Drilling techniques in geothermal science
  - Techniques for producing energy with low temperature water/shallow geothermal energy systems.
  - Geothermal power plants: operators/maintenance/design/material preparation/learning to repair
  - Environmental monitoring and stakeholder engagement: awareness raising/communication
- Softskills:
  - Entrepreneurship: creating/working in geo-startups
  - Communication between different professions, like any good engineer
  - Knowledge of regulations and legislation in the geothermal industry, to engage a work ethics
  - Multilingual and multi-cultural environment