

Educating world-class engineers for the development of Mongolia

T. Hollenberg¹, B. Battsengel¹, and F. Wullkopf²

¹German-Mongolian Institute for Resources and Technology, Mongolia

³Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany

Within the scope of the German-Mongolian commodity agreement of both governments, a binational university, German-Mongolian Institute for Resources and Technology (GMIT) was founded in 2013. GMIT strives to educate internationally recognised engineers and to be a model institution for the Mongolian Higher Education reform. The first courses started at GMIT in 2013 with the Basic Engineering Program which supports students enrolled in Bachelor study programmes with regard to the English language and natural sciences. GMIT started with three study programmes in Mechanical Engineering, Raw Materials and Process Engineering, and Environmental Engineering in the academic year 2014/2015. The first graduates of the university were able to complete their studies in June 2018. In the period from June 2018 to June 2021, a total of 69 students completed their studies with a Bachelor of Science at GMIT. Almost all these students had either found a job for which they were qualified, or had taken up further studies by the end of 2021. In summary, it can be said that the successful absorption of the first four years of GMIT graduates into the Mongolian labour market has significantly improved the visibility of the university within the Mongolian higher education landscape.

INTRODUCTION

Mongolia, which is very sparsely populated with a total population of around 3.2 million (2019) inhabitants, is one of the ten most resource-rich countries in the world. In the southern part of the country - the Gobi Desert - there are gigantic deposits of copper, silver, gold, coal, fluorspar, and other raw materials. Coal, copper, and gold are among the most important deposits and account for about 89% of Mongolia's export economy, and over 20% of the country's gross domestic product. Accordingly, mining is now the most important industrial sector in the country from an economic point of view. But Mongolia also has molybdenum, tungsten, zinc, uranium, and rare earth elements, in the extraction of which China has so far had a monopoly.[1]

Following the first raw materials strategy in 2010, former German Chancellor Dr. Angela Merkel signed a commodity agreement during the first state visit to Mongolia by a German head of government on 13 October 2011. [2] It was intended to ensure access to rare earth elements for German industrial companies. Furthermore, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH of the Federal Republic of Germany, has implemented programme module Integrated Mineral Resource Initiative (IMRI) for mining agreements in cooperation with the Mongolian Ministry of Mining and Heavy Industry.. The programme has supported the national, resource-based development of Mongolia. Within the framework of this programme module, the capacity of national and local partners to create broad and sustainable growth utilising the potential of the minerals and commodities sector has been expanded. [3, 4]

A lighthouse project in line with the commodity agreement between the German and Mongolian governments, the German-Mongolian Institute for Resources and Technology (GMIT) was founded in 2013. The first courses started at GMIT in 2013. The Ministry of Education and Science in Mongolia and the Ministry for Economic Cooperation and Development (BMZ) in Germany are the main responsible authorities. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH has carried out the technical cooperation by implementing the GMIT-Project with the cooperation of DAAD (German Academic Exchange Service). In addition, since 2019, financial cooperation regarding the campus extension was implemented in cooperation with KfW Development Bank. Figure 1 shows the main stakeholders of the GMIT and implementation projects.

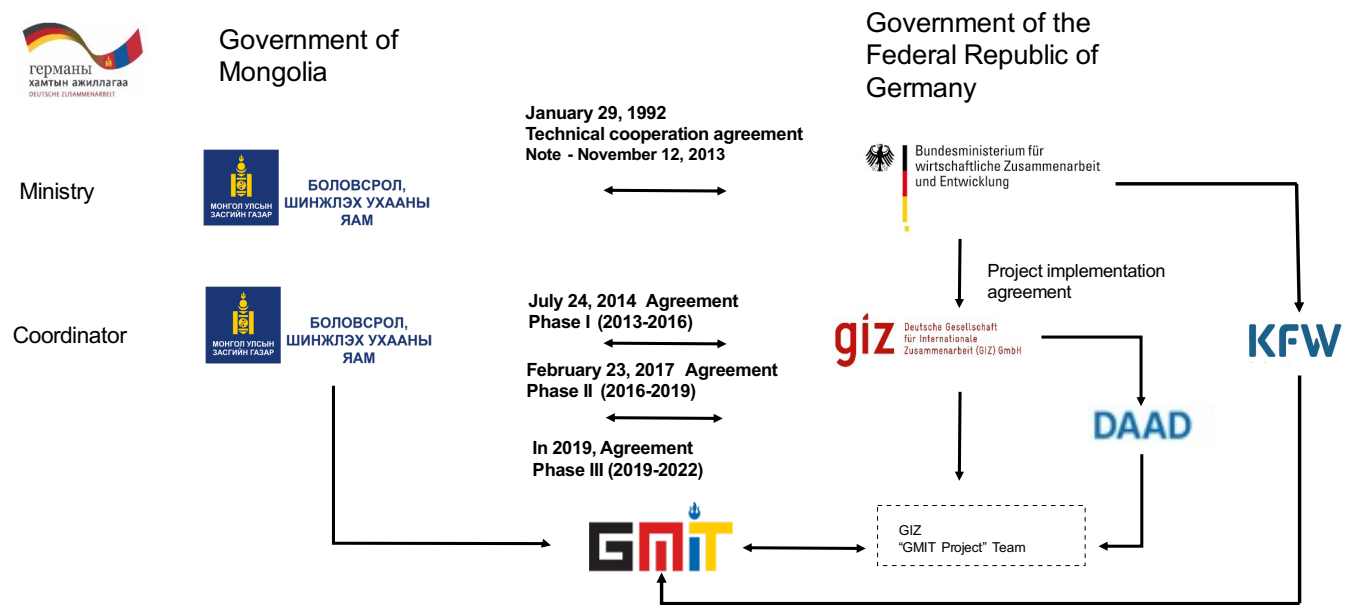


Figure 1. Founders and project coordinators.

GMIT is committed to meeting the needs of the Mongolian mining and processing industries. Furthermore, GMIT strives to educate internationally-recognised engineers, be a model institution for the Mongolian Higher Education reform, and become a leading university of engineering and technology in Mongolia and the Asian region. The organisational structure to support the above-mentioned mission of the university includes the highest decision-making body - GMIT Board of Governors (BoG). The BoG consists of 13 members with voting rights. Currently four members are appointed by the Mongolian government entity in charge of education and three members are appointed by the government of the Federal Republic of Germany. The other six members of the BoG are appointed by the GMIT Rectorate and the GMIT Academic Senate. (Fig.2).

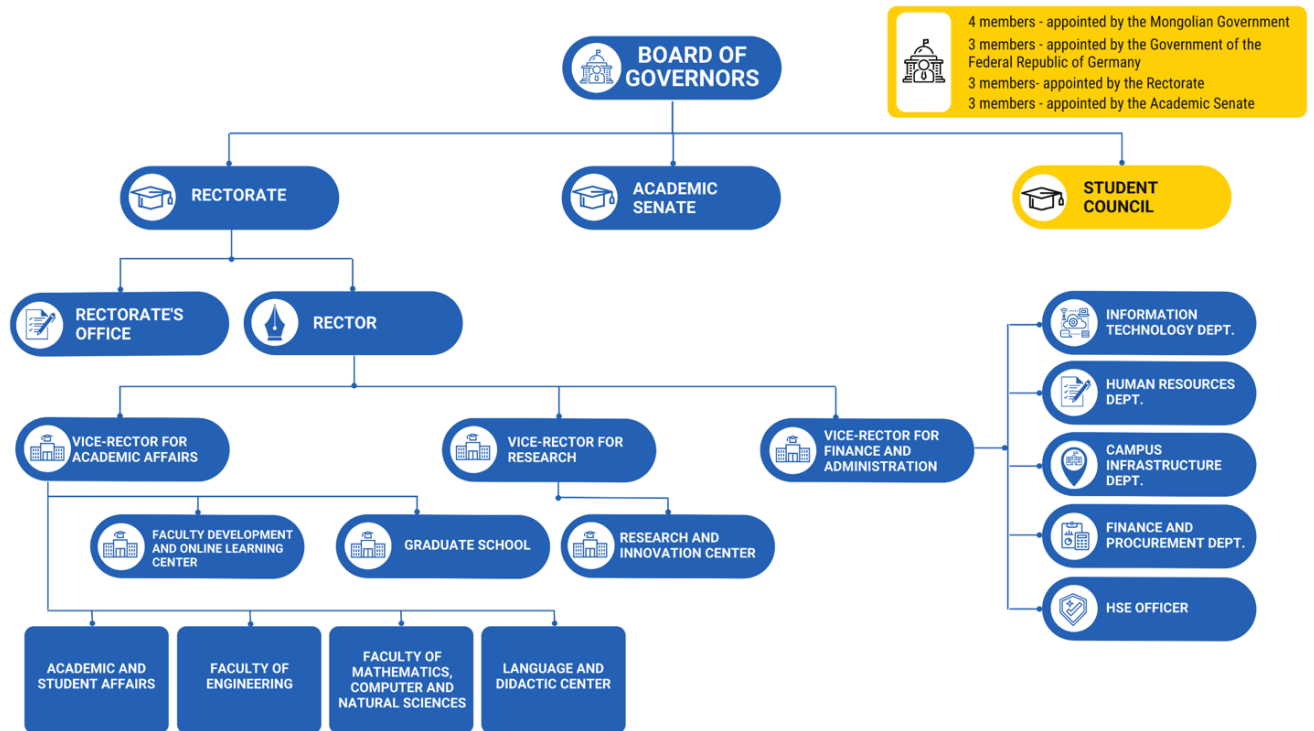


Figure 2. Organisational structure.

Currently, GMIT provides six Bachelor's study programmes in the field of engineering that are internationally accredited by the Accreditation, Certification and Quality Assurance Institute-ACQUIN (Germany) and by the Mongolian National Council for Education Accreditation-MNCEA (Mongolia), and two Master's study programmes in engineering and science, respectively business administration. All courses are conducted in English as the language of instruction. GMIT offers the Bachelor's Study Programmes in Raw Materials and Process Engineering, Mechanical Engineering, Environmental Engineering, Energy and Electrical Engineering, Mechatronics Engineering, Industrial Engineering, and Master study programmes in Master of Business Administration (MBA) in International Management of Resources and Environment (IMRE), Master of Science (M.Sc.) in Resources and Technology.

Due to the admission requirements, some applicants cannot enrol on the GMIT because of the additional preparation needed for mathematics, natural sciences, and English language skills. GMIT offers a Basics Engineering Programme for those students who cannot fulfil the admission requirements for direct enrollment in Bachelor study programmes. It is a preparatory year for GMIT's Bachelor's programme.

The Study Programmes' Development

The necessary professions in the Mongolian labour market have been determined by a market survey of industries and employers in the mining and engineering fields [5]. Based on the survey and the interests of both governments in 2014, three study programmes in Mechanical Engineering, Raw Materials and Process Engineering and Environmental Engineering were developed by Mongolian researchers and German academics from the partner universities RWTH-Aachen, Technical University of Freiberg, Technical University of Darmstadt, and THGA- Applied science university of Bochum. Programme outcomes were developed based on the needs of the respective engineering fields. Required soft skills like intercultural communication, team working, presentation skills, creative and critical thinking as well as engineering ethics were considered for the curriculum development. Basic internships for six weeks and professional internships for 14 weeks in our study programmes are one of the important practise-oriented approaches compared to the engineering programmes in other Mongolian universities. Additionally, the engineering project in the first semester and final study

project in the eighth semester are unique modules which provide knowledge, skills and behaviour required for highly qualified world-class engineers.

We invite the representatives of industries to curriculum development and revision workshops which are conducted every year for developing new programmes or revising the existing study programmes. Currently, all six Bachelor of Engineering programmes are under revision. We want to ensure that all students get the same education during the first two years so that they are able to choose their specialisations after finalising the joint study programme, and the first professional internship of six weeks duration (Fig.3). Based on this proceeding we expect higher flexibility in developing new study programmes and adjusting the programmes to the needs of industry.

CPs	1. Semester	2. Semester	3. Semester	4. Semester			
1	MATH110 Mathematics I 6 CP	MATH111 Mathematics II 6 CP	STAT210 Statistics and Numerics 4 CP (2 UoIL, 2 UoR)	FLME220 Fluid mechanics 4 CP (2 UoIL, 2 UoR)			
2							
3							
4							
5							
6							
7	CHEM110 Chemistry with Labs 8 CP (4UoIL, 2 UoIR, 2 UoILab)	MATS120 Material Science 4 CP (2 UoIL, 2UoIR)	MECH121 Engineering Mechanics II (Dyanmics) 4CP (2 UoIL, 2UoIR)	EEEJ 211 Measurement, Instrumentation, Control Basics 4 CP (2 UoIL, 1 UoIR,1 UoILab)			
8							
9							
10							
11		MECH121 Engineering Mechanics I (Statics) 4CP (2 UoIL, 2UoIR)	THER220 Engineering Thermodynamics 4 CP (2 UoIL, 2UoIR)	CAD 4 CP (1UoIL, 3UoILab)			
12							
13							
14							
15	EEEJ 111 Programming and Algorithm 4CP (1UoIL, 3UoIalabs)	PHYS210 Physics 6 CP	DESN220 Engineering Design 4CP (1UoIL,3UoILab)	Law 2 CP			
16							
17							
18							
19	ENSO200 Engineer in Society (Ethics) 2 CP (1 UoIL, 1 UoIR)		EEEJ 211 Introduction to Electrical Engineering 4 CP (2 UoIL, 2UoIR)	Raw Materials & Recycling 4 CP 2UoIL, 2UoIR			
20							
21	Intercultural Communication % Competence 2 CP (2 UoIR)	Introduction to Geosciences 4 CP	Introduction to Economis 4 CP (2UoIL, 2UoIR)	HSE300 Health-Safety- Environment 4 CP (2 UoIL, 1 UoIR, 1 UoILft)			
22							
23	ENGL100 Technical English 4 CP (4 UoIR)						
24							
25							
26							
27	PROJ140 Engineering Project 2 CP (2 UoIR)	Introduction to Engineering Management 4 CP (2UoIL, 2UoIR)	Introduction to Mining 4 CP	SCIM200 Scientific Methods 2 CP (2 UoIR)			
28							
29	Electives 2 CP (2 UoIR)	Electives 2 CP (2 UoIR)	Electives 2 CP (2 UoIR)	Electives 2 CP (2 UoIR)			
30							
31							
32							
CP total	30	30	30	30			
Legend	CP=	Credit Point	Fundamentals	Specialisation			
	Electives	General	Foreign Language	Internship/ Project/ Thesis			

Figure 3. Joint Study Programme (draft).

Module names according to existing Program							
Semester	Module names	Name of programe					
		Mech Eng (ME)	RMPE	Env Eng (EE)	Indust Eng (IE)	Elect Eng (EEE)	Mecha (M)
Semester 5	Production Process Technology 6 CP	6					6
	Engineering Mechanics III (Mech. Of Mat.) 4 CP	4					4
	Mechatronics & Automation(Contoller) 4 CP	4				4	4
	Heat and Mass Transfer 4 CP	4	4			4	4
	Engineering Mechanics IV (Machine Elements) 6 CP	6	6				6
	Mechanical Process Engineering I + Process Mineralogy 4 CP	4	4	4			
	Introduction to Microbial Biotechnology 4 CP		4	4			
	Properties of Rocks 4 CP		4	4			
	Thermodynamics for Chemical engineering 4 CP		4				
	Principles of Water Management 6 CP			6			
	GIS 4 CP			4			
	Geocology 4 CP			4	4		
	Business Information Systems 6 CP				6		
	Quality Management 6 CP				6		
	Finance I 4 CP				4		
	Entrepreneurship 4 CP				4		
	Project Management 6 CP				6		
	Control Systems 4 CP					4	4
	Electronics 6 CP					6	6
	Circuit analysis 6 CP					6	
	Energy Storage & Conversions 4 CP					4	
	Engineering electives 4 CP/ Language 2 CP			4	4		
	Total CP of 5th	28	26	30	34	28	34
Semester 6	Engineering Mechanics V (Dynamics of Mashinery) 6 CP	6					6
	Virtual Product Design 4 CP	4					
	Hydraulic and Pneumatic Drives 4 CP	4				4	4
	Electric Machines and Drive 4 CP	4	4			4	4
	Energy Systems 4 CP	4	4	4		4	
	Soil Science 4 CP		4	4			
	Mining and Environment 4 CP		4	4			
	Mineral Process Engineering II 6 CP		6				
	Wastewater Treatment 6 CP			6			
	Supply Chain Management 6 CP				6		
	Operations Management 6 CP				6		
	Finance II 4 CP				4		
	Power Electronics 4 CP					4	4
	Industrial Internship + Reflection 10 CP	10	10	10	10	10	10
	Engineering electives 4 CP/ Language 2 CP				4	4	
	Total CP of 6th	32	32	28	30	30	28
Semester 7	Structural Durability and System Reflectability 4 CP	4					
	Production Process Simulation 4 CP	4					
	Finite Element Methods 4 CP	4					4
	Open pit Excavation + Underground Mining Mashines 6 CP	6	6				
	Thermal Unit Operations 6 CP		6				
	Chemical Reaction Engineering 4 CP		4				
	Fossil Fuel Technology 4 CP		4				
	Hydrometallurgy 6 CP		6				
	Water Supply 6 CP			6			
	Air Pollution 6 CP			6			
	Climate Change 4 CP			4			
	Management accounting 6 CP				6		
	Marketing Management 4 CP				4		
	Fundamentals of Strategic Decision Making 4 CP				4		
	International Mining Logistics 2 CP				2		
	Organizational Behavior 4 CP				4		
	Power System Relying & Protection 6 CP					6	
	Professional Electives: Smart Grid 4 CP					4	
	Embeded System 4 CP					4	
	Transmission and Disrtibution Engineering 6 CP					6	
	Digital Signal Processing (<- Signals and systems) 4 CP					4	4
	Software engineering 4 CP					4	4
	Systems Engineering + Network Technology 6 CP						6
	CNC Machines 6CP						6
	Scientific Writing 4 CP	4	4	4	4	4	4
	Engineering Electives 4 CP	8		12	4		
	Business Electives 4 CP				4		
	Language Electives 2 CP						
	Total CP of 7th	30	30	32	32	32	28
Semester 8	Bachelor Thesis Colloquium 12 CP	12	12	12	12	12	12
	Final Study Project 6 CP	6	6	6	6	6	6
	Classifiers and Mixers+Coarse Communication Machines 6 CP	6	6				
	Process Systems Engineering 8 CP		8				
	Solid Waste Technologies 6 CP			6			
	Operation Research 6 CP				6		
	Power Systems Planing Operations and Control 4 CP					4	
	High Voltage Engineering 6 CP					6	
	Robotics 6 CP						6
	Engineering Electives 4 CP	4		4			4
	Language Electives 2 CP	2		2		2	2
	Total CP of 8th	30	32	30	24	30	30
Total CP for 4 Semesters		120	120	120	120	120	120

Figure 4: Restructured and revised Bachelor programmes (draft).

The current revision status of the Bachelor Programmes can be seen in Figure 4. The module descriptions are still in process, therefore there may still be changes. The overall target is the approval of the module handbooks by senate in August 2022, before the next study year 2022/2023. The freshmen as upcoming sophomores have been informed and the interim programme for the third and fourth semester agreed. The new freshmen are starting with the new module handbooks while juniors and seniors continue their studies based on the old handbooks.

Regarding the postgraduate studies, we are planning to develop additional Master of Engineering programmes which are to be studied directly after finalising the Bachelor programmes alongside the already existing Master programmes.

Research Strategy

GMIT aims to become a leading research university – recognised for its multidisciplinary research activities in the field of applied sciences. Areas of research include sustainable mining and minerals, raw material processing, technology innovation, environmental protection, mechatronics, electric motor diagnostics, raw materials economics, production process optimisation, and mathematical modelling. Students are actively involved in GMIT's research projects and are asked to initiate, compete, and fundraise for research projects accordingly.

To increase the academic capacity of the university, a Strategic Research and Development Fund (SRDF) was initiated and financed by GIZ in 2017. The SRDF aims to support research projects of GMIT professors, lecturers, and students by emphasising co-financed activities with Mongolian and international companies. In this way, real-world issues of industrial corporations can be addressed professionally by joint efforts. The Strategic Research and Development Fund supports applied research in Mongolia and fosters strong cooperation between the university and the private sector. To conduct research based on company and Mongolian society needs, there is international and national cooperation with state and private organisations and companies.

Since its early beginnings, GMIT focused on partnerships with first-class academic and research institutions in Germany and Mongolia, as well as Mongolian industries and companies. Important partners are the three German partner universities: Technische Universität Bergakademie Freiberg, RWTH Aachen, and Brandenburgische Technische Universität Cottbus-Senftenberg. Additionally, GMIT cooperates with several Mongolian universities (e. g. National University of Mongolia (NUM) and Mongolian University of Science and Technology (MUST), with governmental/non-governmental entities, as well as with private organisations operating in the industrial sector through joint research and student internships, for example, Oyu Tolgoi, Energy Resource, APU Group, Wagner Asia, MSM, Premium Group, Mongolian Gold Corporation, Transwest, and MERA Group, etc.

The Campus Development

The GMIT has been established as a campus university located in the Nalaikh district.

Being Mongolian's first campus university, almost all students live on the campus. This concept is important for the personal development of each student. Living together means spending time productively and practising teamwork – important skills for the 21st century.

GMIT campus will be extending in upcoming years by building a new dormitory and a multifunctional laboratory building (Figure 5). In the plan design figure, the new multifunctional building (1) will be connected with the existing main building (4).



Figure 5. Campus extension

The dormitory will probably be ready for moving into by the end of July 2022. The construction of the multifunctional laboratory building will be started in the fourth quarter of 2022. The building is planned to have three levels of around 1,700 m² floor space. The ground floor houses seven laboratories for the different programmes as well as research, the first floor houses another four lab areas and the library. The second floor provides lecture rooms. As a result of the campus extension, GMIT will be able to educate qualified experts, which is essential for the development of Mongolia's mining and processing industry, in order to conduct technical and scientific research, and develop innovation. It will bring great benefit to the sustainable development of the German-Mongolian Institute for Resources and Technology, by increasing student numbers, creating a professional environment for teaching, learning and research, and much more.

CONCLUSION

On 13 October 2011, then German Chancellor Dr. Angela Merkel signed a commodity agreement during the first state visit to Mongolia by a German head of government. [2] It was intended to ensure access to rare earth elements for German industrial companies. Furthermore Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH of the Federal Republic of Germany, implemented the programme module Integrated Mineral Resource Initiative (IMRI) for mining agreements in cooperation with the Mongolian Ministry of Mining and Heavy Industry. The lighthouse project in line with the commodity agreement between the German and Mongolian governments was the foundation of the German-Mongolian Institute for Resources and Technology (GMIT) in 2013. The first courses started at GMIT in the same year. The Ministry of Education and Science in Mongolia and the Ministry for economic cooperation and development (BMZ) in Germany are the main responsible authorities and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH has carried out the technical cooperation by implementing the GMIT Project with the cooperation of DAAD. In addition, in 2019 financial cooperation regarding the campus extension was implemented in cooperation with KfW Development Bank. GMIT started with three study programmes in Mechanical Engineering, Raw Materials and Process Engineering, and Environmental Engineering in the academic year 2014/2015. The first graduates of the university were able to complete their studies in June 2018. Regarding the

needs of the raw materials industry in Mongolia, two new programmes were developed – Mechatronics Engineering and Electrical Energy Engineering in 2020. Due to the limited academic capacity, revision and restructuring of the Bachelor programmes was required, which started in February 2022 in cooperation with all programme coordinators. The target is to educate all engineering students during the first and the second year equally so that they can choose their specialisation after the fourth semester. We are optimistic that we will obtain the approval of the GMIT Academic Senate in time to start teaching according to the new module handbooks for the study year 2022/2023.

So far, in the period from June 2018 to June 2022, a total of 112 students completed their studies with a Bachelor of Science at GMIT, and we are looking forward to steadily increasing the student numbers.

REFERENCES

- [1] HOLLENBERG, T., BAYANMUNKH, M., WULLKOPF, F., 2022. Mining in Mongolia 10 years after the German-Mongolian Raw Materials agreement, *Mining Report Glueckauf* 158 (2022), No.3, pp 272-288
- [2] PHOTO GALERY, 2011. Merkel in Mongolia, *Spiegel* 14.10.2011
<https://www.spiegel.de/fotostrecke/photo-gallery-merkel-in-mongolia-fotostrecke-73997.html>
- [3] B. CHIMEG, 2015. Integrated Mineral Resources Initiative to be implemented, *GoGo Mongolia* 27.02.2015, <https://mongolia.gogo.mn/r/144657>
- [4] Projektevaluierung: Kurzbericht Mongolei: Integrierte Mineralische Rohstoffinitiative II, Projektnummer: 2014.2130.4
- [5] Монголын аж ахуйн нэгжүүдэд эрэлт хэрэгцээтэй мэргэжилийн талаар хийсэн судалгаа, IRIM тайлан, 2012, 2013, 2015



Prof. Dr.-Ing. Thomas Hollenberg

Vice Rector for Academic Affairs
German Mongolian Institute for Resources and Technology

Prof. Dr. Hollenberg is a Senior Mining Engineer and Management Expert with more than 30 years professional experience in underground and surface mining. He gained his experience in all types of mining contractor business and specialist mining in a worldwide operating Mining Contractor Company. His final position as Division Manager he held more than 15 years, before he founded and managed his own Mining Contractor and Consulting Companies.

In 2009 Dr. Hollenberg additionally started teaching as visiting lecturer at Clausthal University of Technology and 2016 he became Professor and Director Mining at Namibia University of Science and Technology, Department of Mining and Process Engineering.

In 2020 Prof. Dr. Hollenberg joined the German Mongolian Institute for Resources and Technology in Ulaanbaatar as Program Coordinator for Raw Materials and Process Engineering. Recently he was promoted to Vice-Rector for Academic Affairs.



Prof. Dr. Baatar Battsengel

Rector of GMIT
German-Mongolian Institute for Resources and Technology (GMIT)

Professor Baatar BATTSENGEL is the Rector of the German-Mongolian Institute for Resources and Technology since 2019. She did her PhD in chemistry at RWTH-Aachen in Germany. She has an experience in the higher education system for over 20 Years and published over 50 papers in international journals and conference proceedings. Her current research work focuses on chemical processing and electrochemical extraction of copper and other critical metals. She is a member of the Board of Directors and Vice-President for Education and Research of the International Network of Women Engineers and Scientists since 2020.