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GRÓ Geothermal Training Programme In Iceland: 46 Years Of Worldwide Capacity Building In Geothermal Energy

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ABSTRACT

For 46 years, the Geothermal Training Programme (GTP) in Iceland has been building capacity in all aspects of geothermal development, specifically for developing countries with geothermal potential. Since 2020, it has operated under GRÓ – the International Centre for Capacity Development, Sustainability and Societal Change, under the auspices of UNESCO. Since1979, GTP's cornerstone has been its Six-Month Training Programme hosted in Iceland. By end of 2025, a total of 839 fellows from 68 countries have graduated from the Programme. The Programme provides general geothermal education, with each fellow also receiving specialized training in one of eight focus areas: geothermal geology, geophysical exploration, reservoir engineering and borehole geophysics, chemistry of thermal fluids, environmental science, geothermal utilization, drilling technology, and project management and finance. Each fellow also completes a research project, under supervision of leading geothermal experts in the Icelandic geothermal sector. Since 1999, GTP has supported outstanding fellows for further academic studies in Iceland. By end of 2025, 93 fellows had completed MSc degrees and 7 earned PhD´s. At the same time, 2 fellows were pursuing MSc degrees and 7 PhD´s. In addition to the Iceland based training, GTP has conducted short courses and workshops internationally since 2005. These activities have reached over 3,400 participants through 96 events. The funding of GTP's comes from the Government of Iceland, with supplementary support from international partners and local entities. The impact of the Programme is evident in the professional growth of its alumni, many of whom have become geothermal leaders in their home countries, and in the documented advancements in geothermal energy development across supported regions.

1 INTRODUCTION

The Geothermal Training Programme (GTP) in Iceland was established in 1978 and commenced operations the following year, initially training two fellows through an intensive six-month course. Since its inception, the Programme has specialized in capacity building across all aspects of geothermal science, technology, and resource development, targeting professionals from developing nations with geothermal potential.

For most of its existence, GTP was affiliated with the United Nations University (UNU). In 2020, it was moved under GRÓ – the International Centre for Capacity Development, Sustainability and Societal Change (www.grocentre.is), which operates under the auspices of UNESCO. GRÓ comprises four Iceland-based training programmes: the Geothermal Training Programme (GTP), the Fisheries Training Programme (FTP), the Land Restoration Training Programme (LRT), and the Gender Equality Studies and Training Programme (GEST). The Government of Iceland has been the primary financial supporter of the GTP, with additional contributions from international partners and local companies.

Since 1979, the Six-Month Training in Iceland has remained the core activity of the GTP, conducted annually except in 2020 when it was postponed due to the COVID-19 pandemic. Over the first three decades, the Programme expanded both in scale and scope, increasing the number of fellows and diversifying its training activities. In recent years, the operation has stabilized, while adopting new modalities such as online and hybrid training to broaden accessibility.

The principal objectives of GTP are to:

- Strengthen geothermal expertise in developing countries to facilitate sustainable utilization of geothermal energy resources.
- Provide university graduates working in geothermal development with intensive, field-oriented, specialized training.

- Enhance participants' technical and practical skills through collaboration with Icelandic geothermal professionals.
- Customize the training to meet the specific needs of each participant, their institution, and their home country.

At present, GTP's key activities include:

- Six-month on-site training in Iceland for approximately 25 fellows each year.
- Fellowships supporting MSc and PhD studies at the University of Iceland and Reykjavík University.
- Short courses in Iceland and abroad contributing to the United Nations Sustainable Development Goals (SDGs).
- Support for the Geothermal Diploma Course in El Salvador and comparable regional programmes in Kenya and China, with a possible addition in Indonesia.
- Additional training activities, such as online introductory courses, customized training, and individual capacity-building modules.

The GTP has benefited from strong and consistent leadership since its foundation. Dr. Ingvar B. Fridleifsson served as the founding Director until his retirement in 2013, with interim leadership by Dr. Jón S. Gudmundsson (1986–1989) and Dr. Hjalti Franzson (1981). Lúdvík S. Georgsson, Deputy Director from 1990, succeeded as Director in 2013 and served until 2019. Dr. Gudni Axelsson led the Programme from January 2020 until June 2024, after which the current Director, Bjarni Richter, assumed the role.

For its first 42 years, GTP was hosted by Orkustofnun, the National Energy Authority of Iceland. It now operates under ÍSOR – Iceland GeoSurvey, through a contract with the Ministry for Foreign Affairs via GRÓ. ÍSOR, being a national research institute specializing in geothermal exploration and development, provides an ideal institutional environment for GTP operations. The Programme's academic activities are overseen by an eight-member Studies Board, while approximately 80–90 lecturers and support personnel are engaged annually from Icelandic universities, geothermal research institutes, engineering firms, and energy companies. This broad network of experts constitutes GTP's most valuable resource.

The COVID-19 pandemic significantly impacted GTP operations, resulting in the postponement of the 2020 training course and the cancellation of all in-person international courses in 2020 and 2021, with the exception of the SDG Short Course V in Kenya. Nonetheless, this period catalyzed the expansion of online training, greatly increasing GTP's global reach and accessibility.

This paper provides an overview of GTP's activities and its contribution to geothermal capacity building in developing countries over nearly half a century. More detailed analyses of specific aspects of GTP's operations can be found in Georgsson et al. (2021), Haraldsson et al. (2021, 2023), and Ómarsdóttir et al. (2026), as well as on the Programme's website (www.grocentre.is/gtp).

The GTP remains the longest-running geothermal training initiative worldwide, alongside comparable programmes established in Kyushu (Japan) and Pisa (Italy) in 1970, both originally supported by the United Nations and their respective Governments. The Kyushu programme operated for three decades and was revived in 2016, while the Pisa course continued for two decades. Additional examples include the University of Auckland (New Zealand) training programme, operational since 1978 (with a brief hiatus between 2002 and 2007), and the Iceland School of Energy (ISE) at Reykjavík University, which offers graduate degrees in renewable energy with a focus on geothermal systems. The Geothermal Diploma Course in El Salvador also deserves mention for its long-standing contribution to training professionals across the Spanish-speaking world. The reader is referred to a recent paper by Newson and Green (2019) for further information.

2 SIX-MONTH TRAINING PROGRAMME IN ICELAND

Since its establishment, the Six-Month Training in Iceland has remained the cornerstone of the Geothermal Training Programme (Figure 1). In addition to a comprehensive foundation in geothermal science and technology, each participant undertakes advanced, field-oriented training within one of eight specialized disciplines:

- Geothermal geology

- Geophysical exploration
- Chemistry of thermal fluids
- Reservoir engineering and borehole geophysics
- Drilling technology
- Geothermal utilization
- Environmental science
- Project management and finance

Finally, each fellow completes a twelve-week individual research project conducted under the supervision of one or more geothermal specialists, mainly Icelandic. These projects often utilize data from the participants' home countries, thereby reinforcing the direct application of newly acquired expertise to local geothermal development.



Figure 1. Overview of GTP´s study lines. Generally, four to five specializations are offered each year depending on the focus of participants and institutional priorities.

The Programme begins with a four to five-week introductory module providing a broad overview of geothermal research, exploration, and development covering all the 8 specialisation lines. This phase includes lectures by geothermal experts, short presentations by fellows on geothermal conditions in their home countries, and field excursions to geothermal sites in and around Reykjavík.

Following the introductory period, fellows engage in a about ten-day group project designed to encourage interdisciplinary collaboration and practical problem-solving. The cohort is then divided into four to five smaller groups, each focusing on one of the specialized study lines described above. This eight-week specialization phase provides intensive, hands-on training in the chosen discipline.

Midway through the specialization period, participants join a five-day field excursion through western and northern Iceland, visiting a range of geothermal systems, including high- and low-temperature resources, direct-use installations, and power generation facilities.

The final eleven to twelve weeks are dedicated to the individual research projects. These studies are typically based on real geothermal datasets from the participants' home institutions, ensuring mutual benefit: capacity building for the fellows and tangible contributions to geothermal development in their respective countries.

A key outcome of the Six-Month Training is the production of final project reports, which constitute a significant body of open-access geothermal literature. These reports frequently form the basis of conference presentations and peer-reviewed publications, contributing to the global dissemination of geothermal knowledge. The GTP publication archive, available at www.grocentre.is/gtp/publications, also includes MSc and PhD theses

completed with GTP support, as well as papers resulting from GTP-led short courses and international workshops. Over the decades, this repository has grown into one of the largest open-access databases of geothermal research worldwide, providing invaluable resources for scientists, engineers, and policymakers.

As of the end of 2025, a total of 839 fellows from 68 countries have completed the Six-Month Training Programme (Figure 2). The global distribution of fellows' home countries further highlights the international reach of the Programme.



Figure 2: The 68 home-countries of 1979 – 2025 six-month fellows of the GTP along with the number of fellows per country. The pie chart shows cumulative participation by continent/region over the period.

The number of annual six-month fellows, as well as active MSc and PhD students supported by the GTP, are shown in Figure 3.

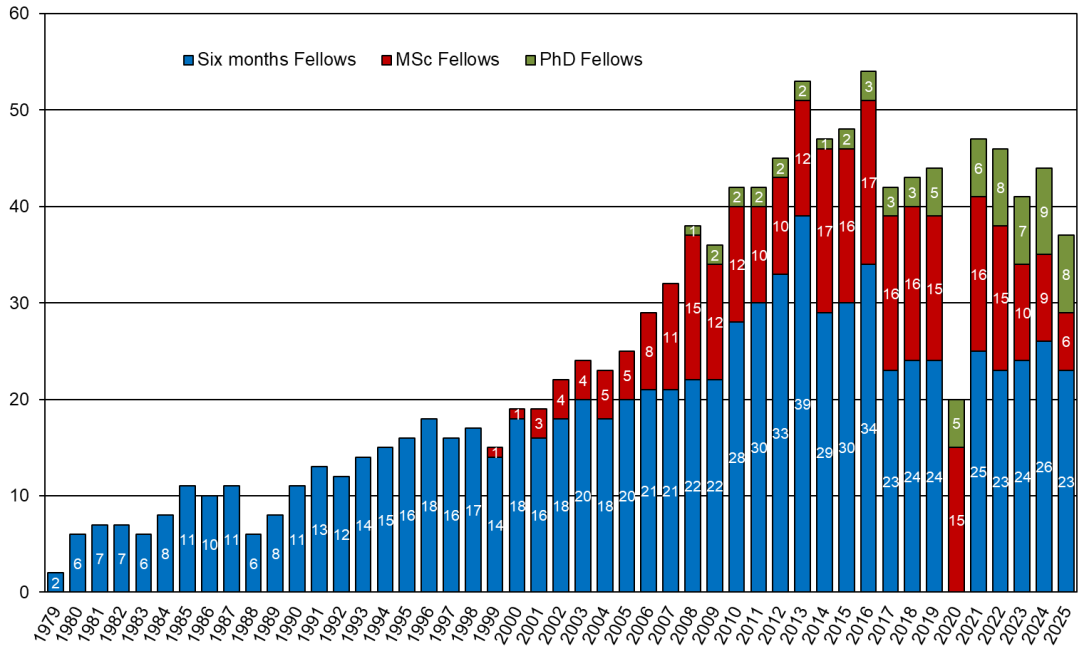


Figure 3: Yearly statistics for the number of GTP fellows, both six-month fellows (blue), MSc- (red) and PhD-students (green) supported by GTP.

3 SUPPORT FOR MSC AND PHD STUDIES

Since 1999, the Geothermal Training Programme (GTP) has provided six-month fellowships to enable outstanding graduates to pursue postgraduate studies at Icelandic universities, initially at the MSc level and, from 2008 onward, at PhD level (Figure 3). By late 2025, a total of 93 MSc degrees and 7 PhD degrees had been completed with GTP support, amounting to 100 fellows who have advanced their higher education through the Programme. At the same time, 2 are pursuing MSc degree and 7 a PhD degree.

GTP maintains formal cooperation agreements with Iceland's two principal universities: the University of Iceland (UI), with an agreement established in 2000, and Reykjavík University (RU), with an agreement signed in 2013. These agreements recognize the six-month GTP training as equivalent to up to 30 ECTS credits, corresponding to 25% of the coursework requirements for an MSc degree. The MSc and PhD fellowships cover living and study expenses in Iceland.

In recent years, approximately 2–3 MSc fellowships and 1–2 PhD fellowships have been awarded annually.

4 SHORT COURSES AND WORKSHOPS

Since 2005, GTP has organized short courses and workshops in Iceland and partner countries, both as recurring activities, primarily in Kenya and El Salvador, as well as targeted training based on specific regional needs. Through 96 events conducted up to the end of 2025, more than 3,400 participants have benefited from these training initiatives.

The Programme expanded abroad through a short-course series supporting the United Nations Millennium Development Goals (MDGs), beginning in 2005 in Kenya to serve African countries. A parallel series was launched in 2006 in El Salvador for Latin American and Caribbean countries. In 2008, a workshop for decision-makers on the direct use of geothermal resources was held in China for Asian stakeholders. Both the Kenya and El Salvador series were updated in 2016 to align with the United Nations Sustainable Development Goals (SDGs). Between 2005 and 2025, more than 1,750 participants attended 35 Short Courses and Workshops dedicated specifically to advancing the UN Development Goals.

The short courses in Kenya, conducted jointly with KenGen (Kenya Electricity Generation Company) and GDC (Geothermal Development Company), have primarily emphasized geothermal exploration, considered the most urgent need in the region. In contrast, the El Salvador series, offered in collaboration with LaGeo, has addressed a broader range of specialized topics. Only one short course has been implemented in Asia, although GTP intends to establish a more regular course series in the region.

Since 2010, GRÓ GTP has also provided tailored, demand-driven training programmes of varying scope, duration, and target groups, funded by Iceland's Ministry for Foreign Affairs, diverse institutions, energy companies, and international development agencies. By the end of 2025, 52 customized workshops, short courses, and extended training programmes had been delivered across four continents, benefiting approximately 1,200 participants.

Since 2013, GRÓ GTP has contributed to the geothermal Diploma Course at the University of El Salvador. Initially in an advisory capacity (2013–2015) and, from 2016 onward, as an implementation partner. This initiative has significantly expanded opportunities for geothermal professionals in Latin America to receive comprehensive, discipline-specific training in Spanish. In 2019 and 2023, GTP also contributed to the Sino-Icelandic Training Programme held in Beijing, China.

The COVID-19 pandemic accelerated the Programme's adoption of online training modalities. By the end of 2025, seven online training activities had been delivered, reaching approximately 450 participants. Online training has thus become an established component of GTP's training portfolio, complementing in-person and blended training modes while expanding access to a broader international audience.

5 BENEFITS OF GTP´S ACTIVITIES

The long-term benefits of the GTP are reflected in the professional advancement of its fellows, many of whom have become leading geothermal specialists in their respective countries. Progress in geothermal development in numerous partner nations, together with successive programme evaluations, provides further evidence of GTP's impact (Ómarsdóttir et al., 2026). While development cooperation and capacity-building initiatives are often assessed using quantitative indicators, such metrics provide only a partial representation of the Programme's outcomes. In energy-related sectors, quantitative evaluation commonly focuses on installed megawatt capacity or the number of operational power plants. Kenya illustrates this approach well: geothermal

electricity generation expanded from 210 MWe in 2009 to 985 MWe in 2024 (ThinkGeoEnergy, 2025), becoming the 6th largest geothermal country in the world in terms of installed capacity for electricity production, primarily through KenGen's development of the Greater Olkaria Geothermal Area. The planned addition of 70 MWe from the Menengai field will bring national capacity to over 1 GWe. Over the past four decades, GTP has provided six-month training to 163 Kenyan professionals, most of whom are affiliated with KenGen.

However, such numerical indicators cannot fully capture the depth of GTP's influence. A qualitative perspective is needed to appreciate the Programme's comprehensive contributions. Fellows admitted to the Six-Month Training in Iceland gain direct exposure to the Icelandic geothermal sector and benefit from close interaction with leading experts possessing decades of practical and scientific experience. Equally important, fellows form a peer network composed of practitioners from across the globe, enabling extensive knowledge exchange rooted in shared professional challenges and diverse technical contexts. The Programme thus serves as a unique platform for international collaboration and mutual learning within the geothermal community.

This global network of professionals has become a defining feature of GTP's success. The training experience allows fellows to step outside their own institutional and cultural environments, broadening their professional perspectives. Iceland being one of the leading countries in geothermal research and utilization gives the fellows a chance to experience with their own eyes what geothermal can provide and how it matters.

In the context of accelerating efforts to achieve the United Nations Sustainable Development Goals (SDGs) and in times of conflict, the Programme also functions as a venue for fostering intercultural understanding. Evidence from the training demonstrates that fellows working toward a common technical goal frequently develop strong interpersonal connections that transcend differences in religion, culture, and ethnicity (Figure 4). Upon returning home, many become advocates for tolerance, cooperation, and informed approaches to energy security.



Figure 4: The 2025 GTP six-month fellows on a fieldtrip in Iceland.

After sharing six months of intensive training, with colleagues from around the world, fellows often acquire competencies such as effective communication, diplomatic engagement, intercultural awareness, and confidence in decision-making. Decades of follow-up experience indicate that numerous alumni have subsequently assumed prominent leadership roles in geothermal research, development, and policy within their home countries.

GTP's activities directly support several UN SDGs, notably Goal 7: "*Ensure access to affordable, reliable, sustainable and modern energy for all*", and Goal 13: "*Take urgent action to combat climate change and its impacts*". The Programme also contributes indirectly to broader objectives, including Goal 1: *"End poverty in all*

its forms everywhere", Goal 3: *"Ensure healthy lives and promote well-being for all at all ages"*, Goal 8: *"Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all"*, and Goal 11: *"Make cities and human settlements inclusive, safe, resilient, and sustainable"*. In alignment with Icelandic foreign policy and GRÓ's institutional mandate, gender equality constitutes a central priority, supporting SDG 5: "*Achieve gender equality and empower all women and girls"*.

During forty-six years of operation, approximately 26% of GTP's six-month fellows have been women. Notably, gender representation has improved significantly in recent years with a gender-based selection policy, reaching nearly 50% in 2021 and 54% in 2024; in the last decade, women accounted for 41% of participants. Among graduates of GTP-supported MSc and PhD programmes, women constitute 27%.

Although energy research and development still remains male-dominated, particularly in many developing countries, GTP actively works to promote gender equity through balanced candidate selection. GTP remains committed to increasing the participation of women in both short-term training and postgraduate studies, with the long-term objective of achieving gender equality across all programme activities.

In 2024, the operations of the GRÓ Centre and its four associated sister programmes underwent an external evaluation conducted by GOPA Worldwide Consultants GmbH. The assessment focused primarily on activities implemented in recent years. Overall, the findings of the evaluation were highly positive, including underscoring the significant role of the GTP in strengthening human capacity in geothermal science and technology within developing countries possessing substantial geothermal potential.

The evaluators concluded that GTP has made a substantial contribution to the development of a skilled pool of geothermal professionals in partner countries. The fellowship programme was found to be in high demand, and its design and management were deemed well aligned with its intended objectives and the needs of its direct beneficiaries.

The evaluation further highlighted the high perceived quality, consistency, and academic coherence of the training provided. In particular, the Six-Month Training Programme was reported to have markedly enhanced fellows' competencies, with the greatest improvements observed in technical proficiency, research capability, and analytical skills.

The selection process for fellows was characterized as rigorous and systematic, involving a detailed review of nominated candidates and structured interviews. The evaluators noted that special emphasis is placed on selecting practitioners who are positioned to meaningfully influence geothermal development in their home countries. As a result, fellows return to their institutions equipped with enhanced expertise and the capacity to promote effective and sustainable utilization of geothermal resources within their areas of specialization.

6 CONCLUSIONS

The strategic direction of the Icelandic Government and GRÓ underscores a continued commitment to strengthening the four GRÓ programmes, including the Geothermal Training Programme (GTP), as articulated in GRÓ's *Theory of Change and Strategic Priorities 2022–2027*. The 2024 GOPA external evaluation further substantiates this direction and offers recommendations that inform the future development of GTP.

For GTP specifically, several priority areas emerge:

- Sustained emphasis on the Six-Month Training Programme remains essential, given increasing global demand for geothermal expertise.
- Expanding participation to new countries, particularly those with non-volcanic geothermal resources and direct-use potential.
- Long-term academic opportunities, such as MSc and PhD scholarships, continue to provide important supplementary capacity-building benefits for selected fellows, their institutes, and partner countries.
- Short courses delivered on-site will be increasingly emphasized, with planned expansion beyond Africa and Latin America to include Asia.
- Strengthening regional training centres, exemplified by the successful El Salvador Diploma Course, presents an opportunity to deepen GTP's global presence, particularly across East Africa and Southeast Asia.

- Tailored short courses designed to meet the specific needs of diverse stakeholders will remain an important aspect of GTP's service portfolio.
- In addition, GTP will further invest in online training, which offers significant potential, from brief lecture-based modules to more comprehensive, long-duration training formats.
- Greater involvement of graduated fellows as instructors and advisors.
- Enhanced collaboration with UNESCO, development institutions, and private-sector actors, will support the Programme's evolving mandate.

Despite recent advances, global geothermal utilization remains modest relative to other renewable energy sources such as solar and wind. Nevertheless, the Earth's geothermal potential is vast and largely untapped. Geothermal resources, if responsibly managed, can supply renewable and environmentally benign energy for extended time frames, spanning decades to centuries. Importantly, geothermal heat is inherently well-suited for direct-use applications, for which global potential is substantial, even from lower-grade resources that are not viable for electricity production. Expanding geothermal utilization in this domain can meaningfully contribute to reducing fossil-fuel dependency and mitigating climate change.

Achieving such expansion requires significant growth in geothermal training and capacity development worldwide. Existing training initiatives, though impactful, operate on a limited scale and must be substantially increased. Integrating geothermal education into mainstream university curricula, while simultaneously strengthening existing programmes and establishing new ones, will be essential.

Equally important is recognizing that geothermal development extends beyond science and engineering; increasing attention must be directed toward public awareness, regulatory frameworks, politics, and business aspects. GTP has already begun integrating these dimensions into its training approach in recent years.

In summary, the GOPA evaluation confirms that GRÓ GTP has produced demonstrable positive impacts in geothermal training and capacity strengthening globally. With continued support from Iceland's development cooperation framework, the Programme is well positioned to expand its reach and to play an increasingly significant role in preparing the skilled workforce necessary for the future growth of geothermal energy worldwide.

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