IGA

ESMAP
Energy Sector Management Assistance Program

IRENA
International Renewable Energy Agency

United Nations Framework Classification for Geothermal Energy

Pilot applications in the Caribbean, Ethiopia and Indonesia

CITATION

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About IRENA

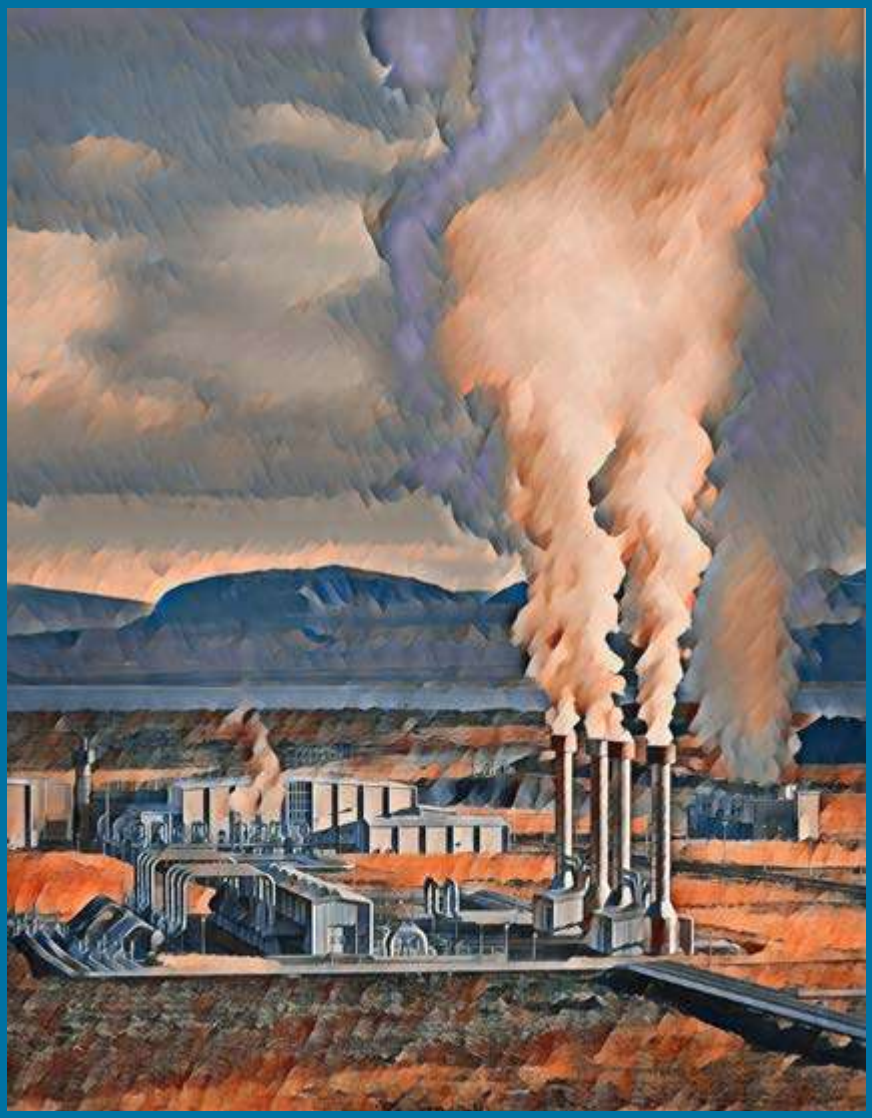
The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. An intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. **www.irena.org**

About the IGA

The IGA is a registered society in New Zealand that operates from Bonn, Germany. The IGA aims at being the leading world authority in matters concerning the research and development of geothermal energy by setting educational standards and offering worldwide energy solutions and in-house technical support, with special support for countries in early stages of geothermal development. The IGA connects the Global Geothermal Community, serving as a platform for networking opportunities aimed at promoting and supporting global geothermal development. The IGA embodies a wide variety of members ranging from academia to industry representatives.

About ESMAP

ESMAP is a partnership between the World Bank Group and 18 partners to help low and middle-income countries reduce poverty and boost growth through environmentally sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank Group's (WBG) country financing and policy dialogue in the energy sector. Through the WBG, ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7) to ensure access to affordable, reliable, sustainable and modern energy for all. It helps to shape WBG strategies and programs to achieve WBG Climate Change Action Plan targets.



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Contents

BOXES, FIGURES AND TABLES

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Executive summary

The lack of worldwide standards, guidelines and codes has hampered consistent and comparable estimation and reporting of geothermal energy potential, leading to ambiguity and limiting the understanding of the viability of geothermal energy projects among potential investors.

To overcome this barrier, the International Geothermal Association (IGA) and the United Nations Economic Commission for Europe (UNECE) jointly set out to develop specifications and guidelines following the broader United Nations Framework Classification (UNFC) for the geothermal sector. The UNFC constitutes a voluntary, three-dimensional system with three key axes describing feasibility, economic viability and geological assessment.

Resource classification is the basis on which coherent and reliable energy policies are formulated by governments to sustainably manage their resources. Classification also makes it easier for industry players to assess natural resource prospects and to appropriately allocate capital.

The classification of geothermal energy resources according to the UNFC guidelines (UNECE, 2009) was adapted to allow a meaningful comparison of geothermal resource estimates with other energy resources. Users of the UNFC geothermal specifications now have a comprehensive system that provides coherent, reliable and globally comparable data, which has the potential to facilitate increased efficiency in policymaking and in public resource management. In addition, users from industries across the world operating in energy markets now have a concise way of evaluating investment prospects in the sector, thereby providing information to secure financing from international capital markets.

Having prepared these specifications and associated guidelines for geothermal energy, and remotely tested them on a selected number of projects, the next phase in their development was to create more awareness in countries, engage stakeholders and further examine their applicability to geothermal projects on the ground.

To accomplish this, the International Renewable Energy Agency (IRENA), the World Bank's Energy Sector Management Program (ESMAP), and the IGA implemented a pilot programme, supported by UNECE, to demonstrate the application of UNFC geothermal specifications and guidelines in three geographic locations: Indonesia (Southeast Asia, 'ring of fire'), the Eastern Caribbean island region and Ethiopia (East Africa, the Great Rift Valley). This project was carried out under the umbrella of IRENA´s Global Geothermal Alliance.

Another objective was to establish a catalogue of on-site experiences, bringing out the best universal practices for UNFC application mechanisms while simultaneously ensuring full local ownership on the ground. This report outlines the insights gained during the project and makes recommendations on how best to proceed.

During the period from March 2018 to February 2019, partners in the project organised training sessions for more than 100 high level and technical stakeholders on the application of the UNFC guidelines to estimate the prospects of geothermal fields in Indonesia (March 2018), a cluster of Eastern Caribbean islands (December 2018) and Ethiopia (February 2019). This contributed to the process of creating a strong network of early adopters in the three jurisdictions. The sessions were organised by the three partners in collaboration with national/regional and local partners.

Key partners in each country or region included:

- the **Bandung Institute of Technology** (Institut Teknologi Bandung, ITB) in Indonesia;
- the **Organisation of Eastern Caribbean States** (OECS) in the Caribbean Islands; and
- the **Geological Survey of Ethiopia** (GSE) and **the World Bank** (Addis Ababa office).

The main conclusion from the three learning experiences in deploying the UNFC to classify geothermal energy resources can be summarised as follows:

- The concepts presented in the UNFC framework are new to most people. Therefore, a tailor-made capacity-building programme should be developed, focusing on knowledge-sharing and awareness-raising.
- Demonstrating the value of the UNFC methodology to classify geothermal resources takes considerable time and effort, mainly due to the need to gather multi-stakeholder groups for workshops to review classifications for the first time.
- The process of devising final classifications following the UNFC methodology takes at least five days. This is the minimum recommended length of face-to-face consultation for participants to acquire the confidence to prepare their own classifications independently (with an IGA expert on hand to lend further advice if requested).
- Geothermal resource quantification must be completed in a way that is consistent with UNFC classification.

If all the data that are important to the UNFC are available – such as project lifetime, status of licenses and financial commitments, off-take agreements, drilling plans etc. – classification will not require any more effort than is usually needed for quantification.

In terms of ownership and who should be trained in order to deploy the process beyond a face-to-face workshop, the following conclusions were drawn:

- national geothermal licensing authorities and financial market regulators are the best organisations to implement UNFCs in any given jurisdiction.
- The key role of such regulators will be to define prerequisite requirements for 'competent persons' issuing reports under the UNFC – these would generally include requirements for demonstrable professional experience and/or certification of some description.

Recommendations to ensure implementation on the ground:

- A follow up with more in-depth campaigns in the visited countries is necessary to continue the exercise; the training requires a bottom-up approach. The hope is that the main findings from the process could convince/encourage countries with geothermal potential to raise local awareness of the UNFC.
- Simultaneously, Partners in the Global Geothermal Alliance may join forces and support the follow-up on this pilot project to further increase capacity development and the application of the UNFC at a national level in countries with transformative geothermal potential.

1 Introduction

The development of geothermal projects is a complex and time-consuming process that requires several experts' (developers, suppliers and regulatory bodies) involvement in setting objectives to achieve project bankability and begin implementation. It encompasses several activities:

Developing adequate geological knowledge, which requires an understanding of the geothermal reservoir conditions – temperature, permeability, flow rate and fluid chemistry – and the associated uncertainties that affect confidence in future resource quantities. Knowledge concerning the resource will allow the developer to conduct extensive technical studies to evaluate the feasibility of extraction at the field.

Establishing socio-economic viability, which requires conducting environmental, economic and social impact assessment studies as per national laws and regulations. This entails extensive public consultations with residents, local government and other stakeholders as part of the project approval process. It also seeks to guarantee economic viability (identification of potential consumer(s), projections of demand growth and accessibility to infrastructure such as roads and grids); and determine financial feasibility by identifying the most cost-effective project design and securing a power purchase agreement as well as the requisite permits and licenses, and initial supplier contracts.

Developing the project, which requires the commitment of funds and installation of all equipment, as per the established design, to begin plant operation and resource extraction.

Although the above activities are well-defined and -intentioned, the lack of relevant worldwide standards and/or guidelines has hampered a consistent and comparable estimation and reporting of geothermal resource potential, thereby generating ambiguity and limiting understanding of the viability of geothermal projects among potential investors, which has undermined funding, including from capital markets.

Many approaches have been proposed for classifying geothermal resources, including those based on accessibility/discovery, geological settings, temperature/use/status, potential, heat-in-place, electric power generation potential, and energy or geological confidence (Falcone et al., 2013; Falcone et al., 2015).

The first geothermal reporting code developed for this purpose was established in 2008 by the Australian Geothermal Energy Association (AGEA) in collaboration with the Australian Geothermal Energy Group and was based on a template from the mining industry. Subsequently, the Canadian Geothermal Energy Association (CanGEA) created a reporting code for the Canadian market, based on the Australian code in 2010, while the Geothermal Energy Association (GEA) created guidelines for reporting on the progress and results of geothermal resource development.

However, because of the broad nature of geothermal exploitation, each of these classification systems has drawbacks and limitations that leave the door open for ambiguity and subjectivity in geothermal resource estimates. As a result, the geothermal industry sought to establish a code – like the UNFC – that should ensure relevant, clear and certified information to support investment decision making.

The UNFC emphasises the creation of resource inventories based on separate categorisations for environmental–socio-economic viability, technical project feasibility and confidence levels, based on geological knowledge and future resource availability. This provides useful classifications for assessing recent, current or potential resource development projects. It also helps with analysing all phases of project development, with the aim determining viability or the need for further analysis and improvement.

The UNFC encourages project development that holistically incorporates: sustainable management of resources (energy and mineral); substantial comparison between energy resources; formulation of coherent and reliable energy policies to realise country-specific objectives on resource sustainability; and evaluation of investment prospects from diverse sources (international or local) by industry players.

2 Current UN framework classification

2.1 UNFC-2009 DEFINITION

The UNFC is a project- and principles-based resource classification system for defining the environmental and socio-economic viability and technical feasibility of projects, as well as encompassing the geological knowledge needed to develop resources. Specifically, it provides a consistent framework to describe the level of confidence in the future yield of a given project in terms of sales or used production, as well as production that is unused or consumed in operations.

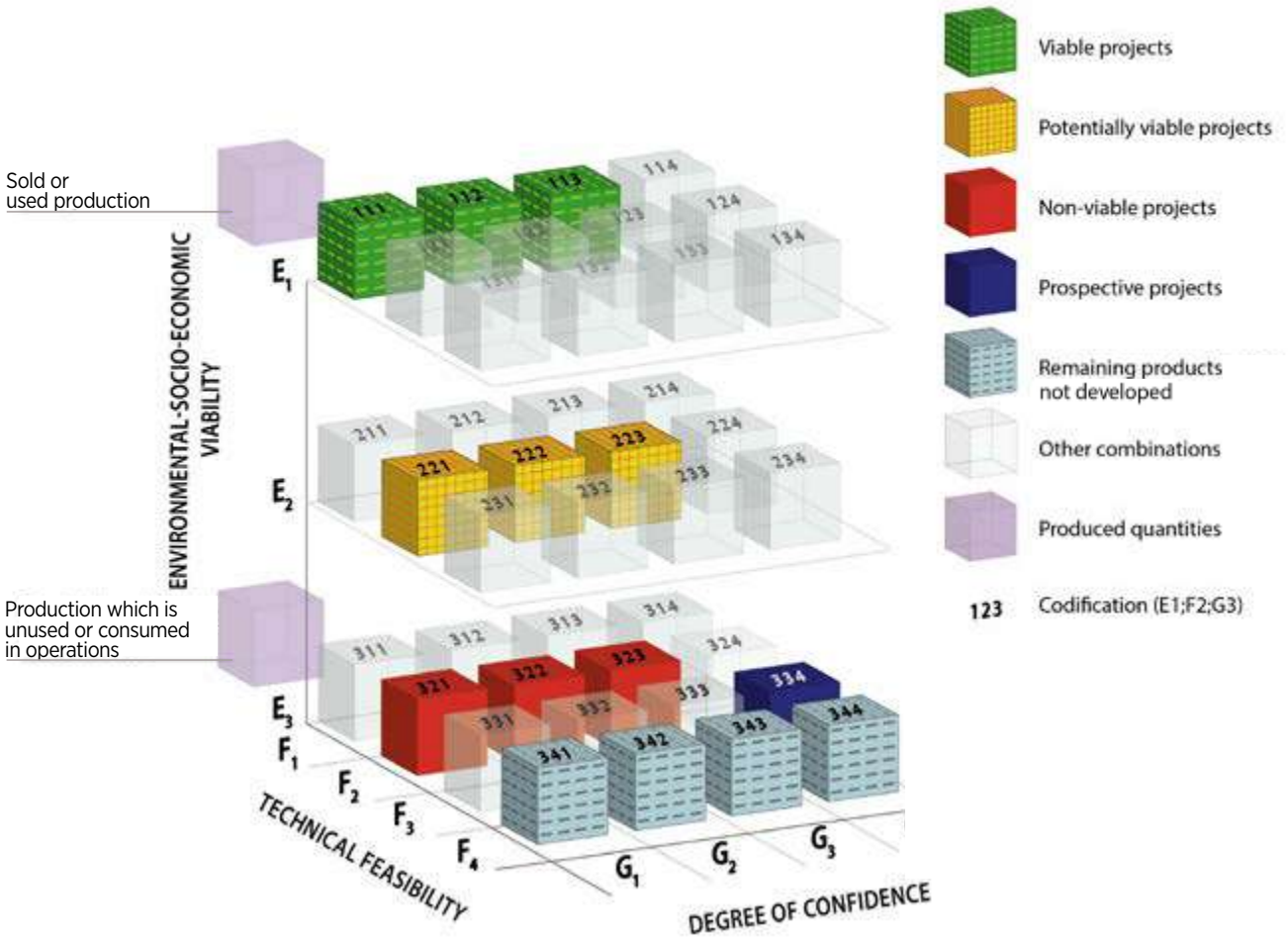
The United Nations adopted its current, general classification framework, the UNFC, in 2009.

The UNFC was developed by the United Nations Economic Commission for Europe (UNECE), which has over 70 years' experience of resource classification and management in Europe. It aims to assist countries, companies or individuals in the sustainable management of energy and mineral resources, including renewable energy, anthropogenic resources and underground storage projects (e.g. carbon dioxide or groundwater). It has been recommended for worldwide use by the United Nations Economic and Social Council (ECOSOC).

Compliance with UNFC requires:

- **Responsible access to, and use of, energy and raw materials that will allow countries to fulfil the Sustainable Development Goals (SDGs) while preserving the environment;**
- **Knowledge concerning the resource; and**
- **Clear documentation of the environmental factors to be considered when planning its exploitation.**

Figure 1: UNFC-2009 categories (after UNECE, 2013)



Axis 1

No commercial viability (E3) → High commercial viability (E1)

Axis 2

Exploration (pre-drill stage; F4) → Drilled resources (high maturity; F1)

Axis 3

Low confidence (G4) → High confidence (G1)

A project that is classified as a F4, G3, E3 is a project that is in a very early stage (F4), with limited knowledge on the resource (G3) and has no defined up-taker in place (E3). On the other hand, a project classified under the UNFC framework as G1, E2, F2 is a project that potentially attracts investments as confidence in the resource is high (G1) and a PPA is in sight (E2), but the resource has not yet been extracted (F2).

2.2 UNFC-2009 PRINCIPLES

At the heart of the UNFC is a three-dimensional system that aims to visualise the maturity of a project (Figure 1). The three dimensions of the system consist of three perpendicular axes with a numbering scheme (see Annex 2):

Axis 1 (E) –Environmental-socio-economic viability

This axis describes the favourability of socio-economic conditions for establishing commercially viable projects by determining the presence of: (a) potential consumers and customers; (b) a power purchase agreement; and (c) delivery infrastructure. For instance, non-commercial projects are those with no commercial viability (level E3), while commercial projects are those close to going to market (level E1); (see Figure 1 and Annex 2).

Axis 2 (F) – Technical feasibility

This axis describes the degree of project development/maturity at the time of evaluation. For example, early-stage project development often refers to a pre-drill stage (level F4), while more mature projects are those with drilled resources and/or those close to coming on-stream (level F1).

Axis 3 (G) – Degree of confidence

This axis describes the level of confidence a project developer has in the geothermal resource of the field. It may encompass data such as geo-scientific information derived from exploration studies, temperature profiles or flow tests results from actual drilled wells. As an example, confidence in the resource is generally low in the early stage of a project (level G4). The more studies are carried out, the more data become available for de-risking purposes, hence the higher the confidence is in the resource potential (level G1).

2.3 KEY ADVANTAGES OF THE UNFC-2009 FRAMEWORK

- A single, language independent framework for reporting the estimates of all resources.
- A full accounting of in-place and recoverable quantities – including commercial quantities, quantities for non-commercial use, sub-economic and technically non-recoverable quantities – that can aid long-term investment decision-making and planning.
- Applicability to renewable energy projects, thus aiding unified reporting of hybrid energy projects.
- Unified reporting of all resource assets – extractive and non-extractive; tangible and intangible.
- Unique guidelines on social and environmental aspects and alignment to the SDGs, thus embracing and responding to global aspirations for good social, environmental and economic outcomes.
- Alignment with the global System of Environmental–Economic Accounting (SEEA), which is being adopted by all countries for reporting national energy accounts.
- Integration of financial reporting with other areas of resource management, such as policy-making, national resource governance and company business process innovation.
- Provides a governance structure under a UN ECOSOC mandate combining the efforts of governments, industry, international organisations and professional societies and associations.
- Alignment with the requirements of resource management at the regional levels of the European Commission and African Union Commission, as well as many national governments.

Figure 2 Sustainable Development Goals (www.un.org)

2.4 OUTCOMES OF IMPLEMENTATION

Users will have a system that provides reliable and globally comparable and coherent data. This will facilitate increased efficiency in policymaking and governmental resource management. A coherent system will also enable the industry to develop projects in different regions of the world using a similar approach. This coherence in communication of resource estimates will simplify access to financing from international capital markets.

The use of the UNFC as a tool for resource management is necessary to fulfil significant Sustainable Development Goals (SDGs) (Figure 2). The classification of resources is the basis on which coherent and reliable energy policies are formulated, allowing governments to manage their resources, industry to conduct its business and capital to be allocated. The attainment of crucial SDGs is dependent on access to sustainable supplies of energy and raw materials.

For example, there exists an important nexus between energy and other sectors such as agri-food, healthcare, environmental protection and industrial development.

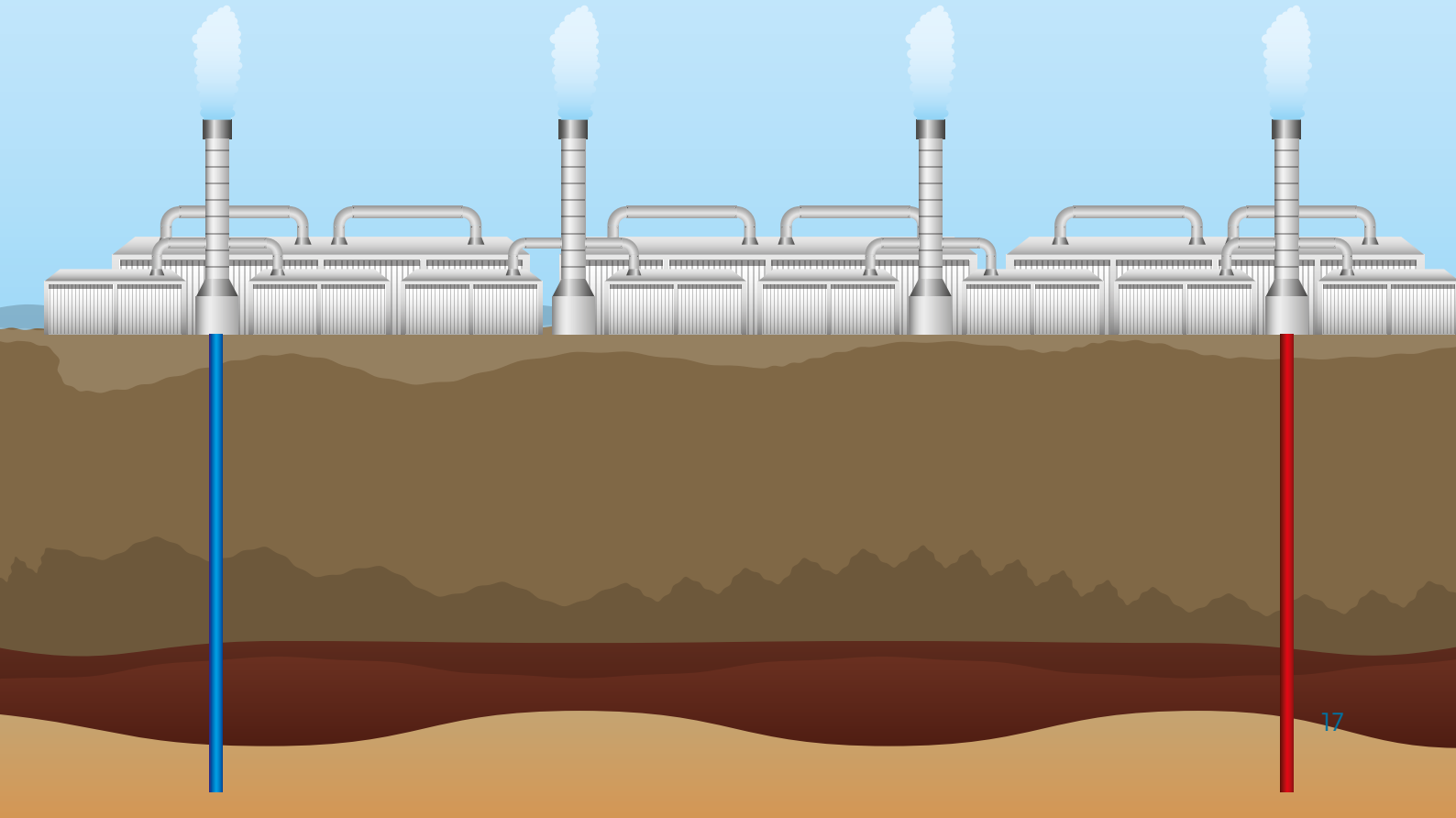
As the UNFC is envisaged to support the development of energy resources, it will contribute to the achievement of the following SDGs:

- zero hunger (SDG2);
- good health and well-being (SDG3);
- clean water and sanitation (SDG6);
- affordable and clean energy (SDG7);
- industry, innovation and infrastructure (SDG9);
- responsible consumption and production (SDG12); and
- climate action (SDG13).

2.5 CHALLENGES TO DEPLOYMENT

Sectors such as minerals and petroleum have their own, long-established systems that have been in use for many decades. The renewables sector has yet to employ a classification and reporting system for resource assessments in the same way as these sectors.

Therefore, establishing universal agreement on the use of a uniform classification and reporting system for all resources is a significant challenge. Overcoming this requires extensive outreach and capacity building using practical examples. However, once newcomers to the UNFC have applied it in a case study they quickly understand its benefits and added value.



3 UNFC-2009 geothermal specifications

Estimating and classifying geothermal potential without the application of worldwide standards, guidelines or codes increases uncertainties concerning compatibility and the risks associated with geothermal energy development.

A common assessment and comparison framework would therefore allow for consistent reporting of geothermal energy potential around the world. The framework must be:

- **flexible enough to permit a comprehensive review of energy sustainability scenarios at project, company, regional, or national level;**
- **transparent** so that investors, regulators, governments and consumers can have confidence in assessments of geothermal energy potential; and
- **consistent with frameworks used for other energy resources**, so that meaningful comparisons can be made across a range of energy options.

A clear framework was needed to overcome ambiguity in reporting geothermal resource estimates and attract broad support from multiple stakeholders.

The International Geothermal Association (IGA), therefore, along with UNECE, set out to adapt the existing United Nations Framework Classification (UNFC-2009) for Evaluating Fossil Energy and Mineral Reserves and Resources (UNECE, 2009) for use with geothermal energy.

The development of the specifications for the application of UNFC-2009 to geothermal energy resources were started in 2014 and finalised in 2016, after which a first round of case studies was developed (UNECE, n.d.). The case studies contain applications of the UNFC in several countries, namely Australia, Germany, Hungary, Iceland, Italy, the Netherlands, New Zealand and the Philippines.

The case studies illustrate the benefits of a generic classification system, since these results are comparable with results from other projects or countries. These application examples (case studies) are offered as guidance for the application and are available in different languages (English, French, Spanish and Russian), (UNECE, 2017).

Once the specifications for renewable energy resources are operational, the UNFC-2009 will be the only classification system in the world that can be applied to all energy resources.

"UNFC users will have a system that provides reliable and globally comparable and coherent data, which would facilitate increased efficiency in policymaking, in governmental resource management as well as for industry in different regions of the world operating in the same markets and through appropriate financing from the international capital markets."

Charlotte Griffiths, UNECE Chief of Section.

4 Applying UNFC-2009 in geothermal pilot projects

"UNFC is user friendly … it helps to have international standard in the classification of the resources, builds investors understanding and confidence, and is good for effective promotion of the resources. The scope of the project attracted us, and we believed it would solve our problem of classifying our huge geothermal resources in a standard way."

Solomon Kebede, Director of the Geological Survey of Ethiopia

The International Renewable Energy Agency (IRENA), the Energy Sector Management Assistance Program of the World Bank (ESMAP) and the International Geothermal Association (IGA) joined forces to implement the UNFC code in a pilot project to increase awareness and demonstrate the UNFC specifications and guidelines in three locations: Indonesia, the Caribbean islands and Ethiopia (Figure 3).

The pilot project was carried out under the umbrella of the Global Geothermal Alliance (see Box 1). Three local organisations – one from each of the pilot locations – were selected and invited to join the pilot project:

- Bandung Institute of Technology (ITB), Indonesia;
- The Organisation of the Eastern Caribbean States (OECS); and
- The Geological Survey of Ethiopia (GSE).

The pilot project also received very generous in-kind support from UNECE, which sent supporting material and documents to the project partners locally and assisted in campaigning for the training through their channels.

The scope of the pilot project for the UNFC geothermal specifications was to:

- build capacity through training of local stakeholders and create ownership of the process on the ground; and
- deploy the UNFC specifications and guidelines at specific geothermal projects – Mataloko in Indonesia, Wotton Waven-Laudat in Dominica (the Caribbean) and Aluto in Ethiopia.

BOX 1. THE GLOBAL GEOTHERMAL ALLIANCE: FOSTERING PARTNERSHIPS TO ACCELERATE DEPLOYMENT

Co-ordinated by IRENA, the Global Geothermal Alliance was launched at COP 21 in Paris and serves as a global platform bringing together 46 governments and 40 partner institutions (as of August 2020) to facilitate the exchange of insights and experiences, foster enabling frameworks and attract investment in the geothermal sector.

The Action Plan adopted by all Member Countries in 2016 envisages four priority action areas: i) mapping of geothermal resources as well as identification of existing and potential geothermal markets and near term projects in the pipeline; ii) scoping the need for assistance to countries with transformative potential, with a view to contributing to the removal of obstacles in terms of policy, regulation, funding or capacity building; iii) supporting the development of effective enabling frameworks and associated mechanisms to achieve national objectives for geothermal energy deployment; and iv) establishing a robust global network of geothermal practitioners building upon existing networks. Additionally, the Alliance aims to promote geothermal energy's role in supporting decarbonisation strategies and the implementation of members' Nationally Determined Contributions.

For further information see: www.globalgeothermalalliance.org

Figure 3: Geothermal pilot projects: Indonesia, the Caribbean islands and Ethiopia

This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply any official endorsement or acceptance by IRENA.

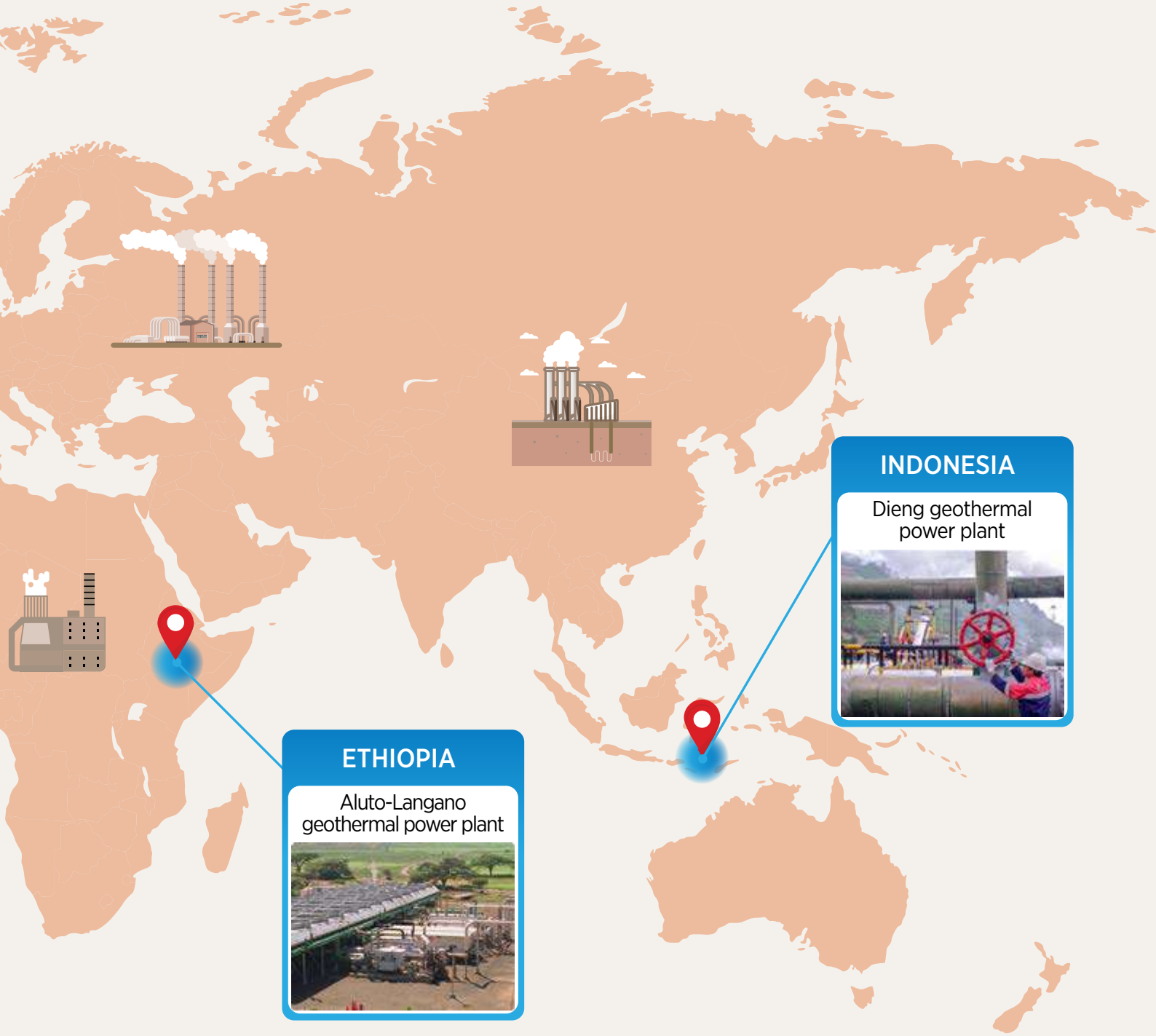


Photo credits
Roseau Valley geothermal site
Photograph: Government of Dominica
Aluto Langano geothermal 9MW power plant, Ethiopia
Photograph: CSI Energy Group
Dieng geothermal power plant, Indonesia
Photograph: Shutterstock

Wayang Windu Geothermal Power Plant, Bandung, Indonesia.
Photograph: Shutterstock

4.1 INDONESIA: MATALOKO GEOTHERMAL PROJECT

Indonesia was the first country selected by the partners for the UNFC pilot project, taking advantage of the opportunity to run the UNFC training sessions in partnership with the annual ITB International Geothermal Workshop (IIGW) held in Bandung on 21–22 March 2018, at which many stakeholders from the Indonesian geothermal sector would be gathered. The training was extended by one day beyond the duration of the IIGW under the formal request of the IGA to the Indonesian Geological Agency (Badan Geologi) to provide the venue and logistical support.

The Mataloko project was the designated geothermal field for this application. This field of high geothermal potential lies in the Bajawa area of Flores Island, which has modest electricity demand and modest demand growth.

The concession to develop the geothermal field is held by PT PLN (Persero), the Indonesian state-owned power generation, transmission and electrical sales company, which utilises a small portion of the geothermal resource.

Training sessions

The sessions dedicated to the UNFC pilot project comprised:

- a 20-minute presentation in the Plenary session of the IIGW on Wednesday 21 March;
- a half-day short course as part of the IIGW program on Thursday 22 March, where 83 participants (including the IGA trainers) representing a wide cross section of Indonesian geothermal sector stakeholders were registered to attend the introduction to the concepts of the UNFC; and
- a full day workshop at the Indonesian Geological Agency (Badan Geologi) on Friday 23 March where 30 participants (including the IGA trainers) were registered. However, a high proportion of the participants had not attended the previous day's short course.

The main challenge to the training was the difference in the number of attendances at each session, which could be attributed to the intended 'hands on' nature of the full day workshop, the importance of participants attending the previous days' short course training session, and the critical role that development companies would play in the classification process. The outcomes subsequent to the training session were as follows:

- Consequent exposure and education have been made possible through two channels after the in-country events. Firstly, a team of nine ITB students (Appendix 4) volunteered to apply the UNFC classifications guidelines to several of the Flores project areas. This exposed the students to the challenge of assembling all the necessary data and information to conduct classifications and gave them valuable practical experience. Despite their enthusiasm and efforts, however, they were ultimately unable to deliver classification reports due to lack of access to critical information held by the project developers. Secondly, the Indonesian Geothermal Association (INAGA) facilitated contact between the IGA and Perusahaan Listrik Negara (PLN), Indonesia's state-owned electricity company and the major geothermal project developer in Flores.
- As part of a New Zealand Government funded program in Indonesia, IGA experts are continuing the work with the Indonesian Geological Agency (BG), which is keen to understand and implement UNFC principles. For example, the New Zealand consultants spent three months (July through September 2019) preparing workflows for applying UNFC classification to 330 geothermal areas that are in the exploration stage. This is being done in several phases, allowing the various stages of exploration to be taken into account as well as project maturity, market development and social-economic opportunities. While there is still a long way to go, the workshop on UNFC application in 2018 stimulated this action.

UNFC-2009 classification

The result of the application of the UNFC code to the Mataloko geothermal field is presented below:

E-axis: Environmental-socio-economic viability

E2 – extraction and sale of geothermal energy is expected to become economically viable in the foreseeable future based on:

- an analysis of electricity demand growth projections that indicated the existence of market for power; and
- a feasibility study that assessed the likely economic viability of the expected project.

F-axis: Technical feasibility

F3 – feasibility of extraction cannot be evaluated due to limited technical data.

G-axis: Degree of confidence

G4 – estimated resource quantities associated with the potential deposit were, based primarily on indirect evidence because:

- the existence of geothermal resources has been indicated by surface studies and six exploration wells drilled to a depth ranging from 162 m to 760 m.

Although most wells are drilled to a shallow depth, it was inferred that the deepest well encountered the top of the main geothermal reservoir at 700–760 m depth due to the occurrence of reservoir minerals. Therefore, there is high confidence that a reservoir exists, but this is yet to be tested with deep wells to assess the temperature, pressure and potential well productivity.

The Valley of Desolation, Dominica, in the Caribbean.
Photograph: Shutterstock

4.2 CARIBBEAN: WOTTON WAVEN-LAUDAT GEOTHERMAL PROJECT

The Caribbean islands were selected by the partners as the second location for the UNFC pilot project. This decision sought to take advantage of an opportunity to carry out the UNFC training course within the framework of the Geothermal Energy Roundtable that took place on 5–7 December 2018 in St Lucia. The geothermal energy dialogue brought together the sector's key experts and decision-makers in the region to help advance and initiate regional co-operation to advance geothermal energy development. The discussions focused on the status of OECS geothermal projects and the opportunities, challenges and underlying risks, with a view to highlighting risk mitigation and financing options.

The Wotton Waven-Laudat geothermal field was designated as the focus for the UNFC pilot project. This field of high geothermal capacity lies in the southern part of the island of Dominica, which has modest electricity demand and demand growth. The proposed development, consequently, would only utilise a small portion of the indicated subsurface energy source.

The Wotton Waven-Laudat geothermal field has been explored since 2006 and five wells have been drilled to date, proving that an extensive productive reservoir exists. An initial development of about 7 MW has been planned based on existing wells for production and injection. The project's technical and financial feasibility has been demonstrated, loan funding has been secured, a special purpose geothermal development company established, and permits for development are either in place or expected to be soon.

Engineering, design and procurement preparations are underway. Various options have been considered for the subsequent development of a larger project – possibly of 50 MW capacity – that would involve exporting power via sub-sea cable to neighbouring islands with greater demand.

Training session

The two-day programme took place on 6 and 7 December 2018 in St Lucia at the Harbor Hotel in Castries. It included:

- a half-day session to provide the participants with definitions for the terminology to be used throughout the classification; and
- half-day and full-day sessions defining the parameters on the E-axis, F-axis, and G-axis of the UNFC classification scheme, with the Wotton Waven-Laudat geothermal field as the main example.

The training workshop introduced the UNFC classification to the participants and provided valuable feedback, comments and suggestions on the geothermal specifications, especially in the Caribbean context.

The training participants demonstrated a relatively good understanding of the concept and context of the UNFC, as well as good knowledge on all aspects of the geothermal project, and provided relevant data for the classification.

Some of the insights gained from the training session based on the Dominica project are as follows:

- application of the UNFC specifications to the participant's own projects prompted inspiring discussions, as well as group exercises to come up with actual classifications for the E and F axes.
- The real added value of the training, according to many participants, was 'to have all geothermal stakeholders in the room so that the finer details of the project could be discussed`.
- The G-axis of the UNFC classification scheme required more discussions around the main elements of the UNFC.

UNFC-2009 classification

For the Wotton Waven-Laudat geothermal field, the result of the application of the UNFC code is:

E-axis: Environmental Socio-economic viability

E1 – extraction and sale of geothermal energy has been confirmed to be economically viable:

- through government subsidies and/or other considerations considering the current and future market conditions; and
- the project has undergone a full financial feasibility assessment, has passed its environmental assessment, has all permits in place (or expected to be resolved in in reasonable timeframe), and funding has been confirmed.

F-axis: Technical feasibility

F2 – feasibility of extraction is subject to further evaluation because:

- capital funds have been committed and implementation of the development project or mining operation is underway; and
- the project is fully defined, all wells drilled, feasibility studies completed, and procurement in progress.
- However, the F-axis classification is not conclusive, because the actual generation from this project has uncertainties due to the following factors:
  - The final capacity of the project, assumed at present to be 7 MW (6.4 MW net), is not confirmed.
  - While the project can provide base load, it may face initial restrictions on local demand and the ability to move power wherever and whenever required on the island grid. The World Bank has reported that annual electricity generated from the 7 MW geothermal plant is expected to be 51.2 GWh per year. This calculation is based on an availability factor of 96% for the geothermal power plant and a load factor starting at 75% with a 3% annual increase based on GDP growth projections."

G-axis: Degree of confidence

The final classification of the G-axis is part of an ongoing discussion and process due to lack of data.

Aluto Langano Geothermal Power Plant, Ethiopia.
Photograph: CSI Energy Group

4.3 ETHIOPIA: ALUTO-LANGANO GEOTHERMAL FIELD

Ethiopia, because of its high geothermal potential, was the third site selected for the UNFC pilot project.

Various geological, geochemical and geophysical studies were conducted in Ethiopia in the early 1970s to discern its geothermal resource base. During the early 1980s, eight geothermal wells were drilled to a maximum depth of 2,500 m. Five of those wells were successfully tapped for geothermal fluids, indicating the existence of temperatures as high as 350°, and four of those proved productive.

In 1998, a two-turbine pilot plant was installed, with a net capacity of 7.3 MWe. Issues related to corrosion, blockages and leakages arose several times after installation, with the result that the plant subsequently fell out of operation.

However, further geothermal development is planned in the Aluto-Langano geothermal field – including the construction and commissioning of a nominal 35 MW power plant.

The UNFC workshop took place on 6–7 February 2018 in Addis Ababa, having been organised by the IGA in partnership with the Geological Survey of Ethiopia (GSE) and the African Geothermal Center of Excellence (AGCE). A one-day roundtable event was added prior to the UNFC workshop, under the request of GSE and AGCE, to capitalise on the opportunity to showcase geothermal energy to the government, IRENA, the World Bank, and other donors and stakeholders – including private developers – whilst organising the UNFC technical training.

The Aluto-Langano field was chosen for the pilot application. This field is located within the central-southern part of the main Ethiopian Rift (lake district), about 200 km south east of Addis Ababa, in the low plain of the Ethiopian Rift. The planned Aluto Geothermal Project aims to build and commission a nominal 35 MWe power plant.

Training sessions

The UNFC training workshop comprised:

- a half-day session to provide the participants with definitions for the terminology to be used throughout the classification; and
- half-day and full-day sessions defining the parameters on the E-axis, F-axis, and G-axis of the UNFC classification scheme, with the Aluto-Langano project as the main example.

As most participants – such as the representatives from the utilities – were not familiar with the technical aspects of geothermal energy and the UNFC code, no classification was completed on-site.

UNFC-2009 classification

The results of the application of the UNFC-2009 code for the planned Aluto-Langano geothermal project are presented as follows:

E-axis: Environmental socio-economic viability

E1 – the extraction and sale has been confirmed as economically viable because:

- the project has undergone a full financial feasibility assessment, has passed environmental assessment, has all permits in place (or expected to be resolved in reasonable timeframe), and funding has been confirmed.

F-Axis: Technical feasibility

F2 – the feasibility of extraction is subject to further evaluation because:

- further studies are required to refine the definition of the geothermal project, including actual locations of the wells to be drilled; and
- project activities around the geothermal business case are ongoing to justify development in the foreseeable future.

G-Axis: Degree of confidence

The final classification of the G-axis is part of an ongoing discussion and process due to lack of data.

5 Wider UNFC applications for geothermal energy

OUTCOMES OF WORKSHOP SESSIONS

There was broad interest in, and a willingness to learn about, the UNFC from industry, government and academia. Almost every participant recognised the need for a global, harmonised scheme for classification and reporting, and that the UNFC offers many advantages as a scheme.

While initially perceived as a simple system, many questions arose during practical exercises for classifying real geothermal projects. The difference between classification and quantification initially proved difficult to untangle. Yet, once the role of the UNFC was clarified – *i.e.,* that it is about classification not quantification – other elements fell into place more easily.

Participants who completed the previous training sessions became familiar with UNFC terminology and concepts, and gained rudimentary experience in implementing it. But no participant attained sufficient confidence or knowledge to implement UNFC for reporting without further experience and expert training.

The basic concepts of classification are easy to present and easy to understand. The full UNFC system, however, is composed of several levels of documents and explanatory guidelines and guidance notes.

There are still a few challenges to solve within the UNFC system that pose specific issues for classifying geothermal energy resources, such as the quantification of the geothermal resource, as this requires a method that is not yet universally accepted and applied. Therefore, the geothermal community focuses on simplifying the workflow on quantification, allowing the geothermal resource assessment (G-axis) to be mapped into the classification process more easily.

Knowledge transfer could be enhanced with succinct, geothermal specific guidelines, flow charts (dynamic or static), glossaries and definitive advice on how to interpret some of the more ambiguous parts of the system.

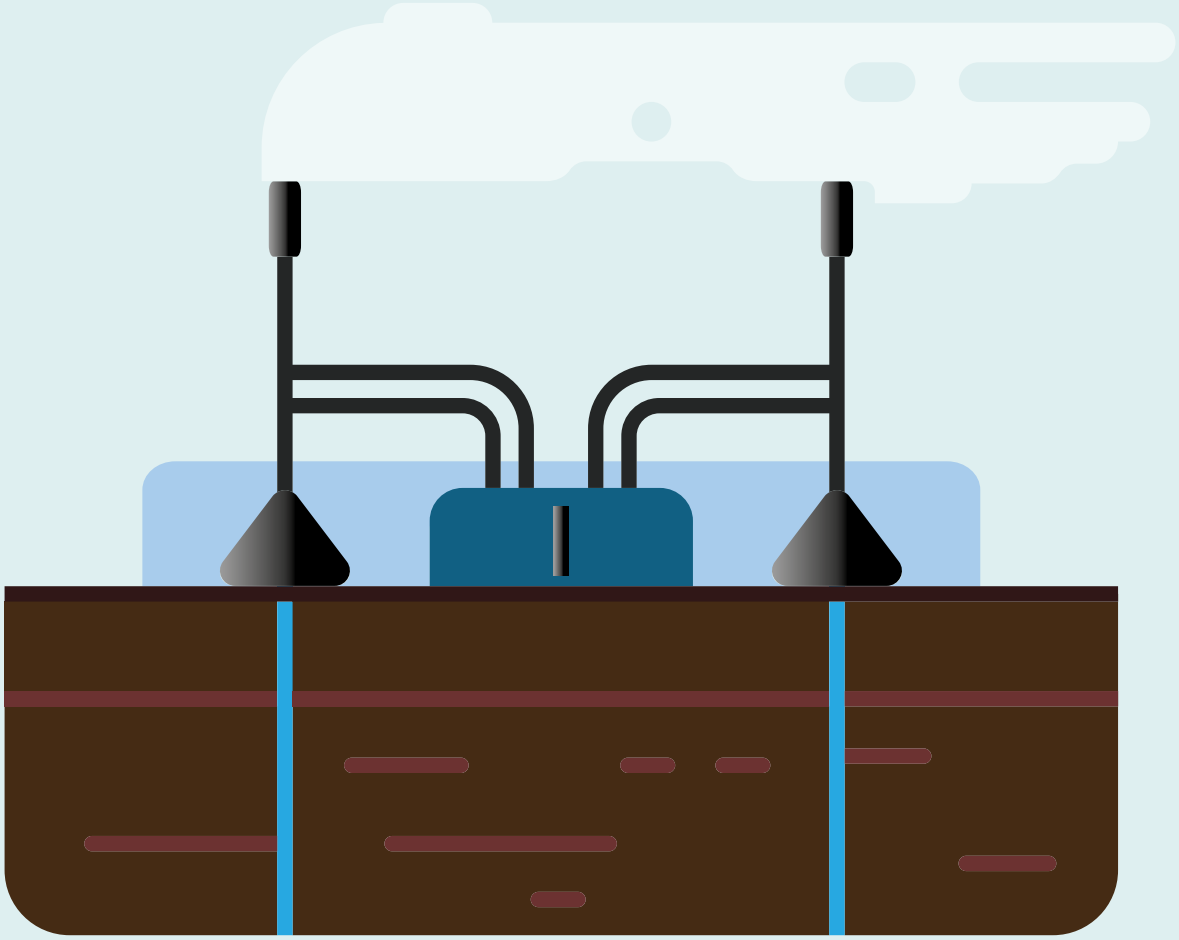
THE WAY FORWARD

Given this background, and the lessons learned from the pilot projects, a well-designed and executed five-day training course could, in principle, impart sufficient knowledge and confidence for participants to independently classify and report geothermal energy resources using the UNFC. The course should be led by at least one person who has undergone some training on the UNFC system. Growing a network of trainers and specialists to draw upon as mentors and peer reviewers of classification reports would be valuable for enabling more completions.

Energy industry regulators or financial market regulators are the best organisations to implement the UNFC in any given jurisdiction. The key role of such regulators will be to define prerequisite requirements for 'competent persons' issuing reports under the UNFC.

These would generally include requirements for demonstrable professional experience and/or certification of some description. UNECE, based in Geneva, provides generic advice for local regulators, considering defining such requirements, but the IGA should play a lead role in helping regulators translate the generic advice into specific requirements for geothermal reporting.

A follow-up project should raise awareness regarding the UNFC classification and its benefits to stakeholders and projects, and place more emphasis on capacity building prior to application in actual fields. Hence, it should aim to: initiate public awareness campaigns for all categories of stakeholder (including financiers and decision makers at country or project level); intensify efforts to establish the capacity and qualification needs of potential geothermal prospect evaluators or assessors; and initiate technical capacity building programmes in geothermal rich countries to develop a pool of experts capable of assessing and signing off classification reports.



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ANNEX 1: Implementing partners

INTERNATIONAL GEOTHERMAL ASSOCIATION (IGA)

"We are of the opinion that the UNFC offers the needed framework to create insight into the project stage and will put the spotlight on the financial potential of the geothermal business case. We can only deploy the UNFC collaboratively, constructively and with full commitment. Standards, focus on market-readiness and creating bankable projects is what we need to do as geothermal community. However, before we are able to do that, we need to make sure the UNFC is carried by organisations on the ground. In order to get that done, similar to the objectives of IRENA, ESMAP and UNECE, we need to build the capacity first."

Alexander Richter, IGA President, 2016-2020 "The World Bank's Energy Sector Management Assistance Program (ESMAP)".

The IGA is a registered society in New Zealand and operates from Bonn, Germany. The IGA aspires to be the leading world authority in matters concerning the research and development of geothermal energy by setting educational standards and offering worldwide energy solutions and in-house technical support, with special support for countries in the early stages of geothermal development.

The IGA connects the Global Geothermal Community, serving as a platform for networking opportunities aimed at promoting and supporting global geothermal development. The IGA embodies a wide variety of members ranging from academia to industry representatives.

INTERNATIONAL RENEWABLE ENERGY AGENCY (IRENA)

"UNFC geothermal specifications provide a standardised format of reporting geothermal resource estimates which allows for comparison with other projects across different countries and resource types and increases the credibility of information about geothermal prospects. This could support investors in making investment decisions. It enables the government and other relevant authorities to target specific sub-sectors of the value chain in a bid to improve the viability of geothermal projects. For example, in a country or region with good resources but where the factor stalling the development of geothermal projects is the absence of a tariff regime, the holistic construct of the UNFC classification scheme ensures that this matter would be captured from several of these prospects across the country or region. In this regard, a move to adequately price geothermal products (electricity, heat and other bi-products) could benefit several of the geothermal projects in the country or region at a time.

The initial scope of the pilot deployment project for the UNFC geothermal specifications was to support the uptake of standardised communication of geothermal projects and prospects in a way that lends them to easy evaluation by participants of capital markets. The project was designed to increase awareness and knowledge about the UNFC classification guidelines for geothermal projects and prospects, and to pilot its application in three of four major emerging geothermal markets. The outputs of the UNFC classification were to be made publicly available through international platforms such as IRENA's Global Atlas for Renewable Energy."

Abdulmalik Oricha Ali, programme officer at IRENA, 2014-2020.

IRENA is an intergovernmental organisation that supports countries in their transition to a sustainable energy future.

IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy – including geothermal – in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. IRENA encourages governments to adopt enabling policies for renewable energy investments, and provides practical tools and policy advice to accelerate renewable energy deployment. The piloting of the UNFC specifications for geothermal energy was carried out under the umbrella of the Global Geothermal Alliance – an initiative of IRENA. The Alliance enhances co-operation, dialogue and co-ordinated action among geothermal stakeholders, both from the public and private sectors, in order to achieve accelerated deployment of geothermal energy for electricity and direct use.

THE WORLD BANK'S ENERGY SECTOR MANAGEMENT ASSISTANCE PROGRAM (ESMAP)

"The geothermal sector is small and disorganised, and one of many barriers to scaling it up is that there is no common language to use when discussing geothermal resources. There are several country-wide resource assessments that are presented more as aspirational goals or political agenda[s] rather than results of scientific studies. Potential investors or financiers can take a long time to understand what it means when a developer refers to their resource as having a potential of XX megawatts or proven reserves of YY megawatts. When there are many renewable energy investment options available, often with lower risk profiles, geothermal energy needs to make its case clearly and simply. The sector must adopt consistent language for communication between developers, regulators, financiers and investors. ESMAP had already committed to supporting the development of the UNFC before I joined in October 2014, and it was done in the hope that it could fill this role."

Thrain Fridriksson, project manager at ESMAP.

ESMAP is a collaboration between the World Bank Group and 18 partners to help low- and middle-income countries reduce poverty and boost growth through environmentally sustainable energy solutions. ESMAP's analytical and advisory services are fully integrated within the World Bank Group's country financing and policy dialogue in the energy sector. Through the WBG, ESMAP works to accelerate the energy transition required to achieve Sustainable Development Goal 7 (SDG7) to ensure access to affordable, reliable, sustainable and modern energy for all. It helps to shape WBG strategies and programs to achieve WBG Climate Change Action Plan targets.

Another advantage of the UNFC is that it allows comparison with other energy resources. There is a clear advantage to having a system for this purpose that is not specific to geothermal. This product is far more likely to succeed when it can be readily understood by people who are already active in the energy sector.

Local partners

THE BANDUNG INSTITUTE OF TECHNOLOGY (INSTITUT TEKNOLOGI BANDUNG, ITB)

is a research university located in Bandung, Indonesia. Established in 1920 as the Technische Hogeschool (TH), the present institute was founded in 1959 by the Indonesian government as an institution of higher learning of science, technology and fine arts, with a mission of education, research and service to the community.

THE GEOLOGICAL SURVEY OF ETHIOPIA (GSE)

was established in 1968 as a Department within the Ministry of Mines and is responsible for collecting basic geoscience information from the whole country and disseminating it to all stakeholders.

THE ORGANISATION OF EASTERN CARIBBEAN STATES (OECS)

founded in 1981, is an inter-governmental organisation dedicated to regional integration in the Eastern Caribbean. Currently, the OECS consists of eleven members Antigua and Barbuda; Commonwealth of Dominica; Grenada; Montserrat; The Federation of St. Kitts and Nevis; Saint Lucia; St Vincent and The Grenadines; British Virgin Islands; Anguilla; Martinique and Guadeloupe.

ANNEX 2: UNFC-2009 system categories

E-AXIS: ENVIRONMENTAL-SOCIO-ECONOMIC VIABILITY	
E1	Extraction and sale has been confirmed to be economically viable.
E2	Extraction and sale is expected to become economically viable in the foreseeable future.
E3	Extraction and sale is not expected to become economically viable in the foreseeable future, or evaluation is at too early a stage to determine economic viability.
F-AXIS: TECHNICAL FEASIBILITY	
F1	Feasibility of extraction by a defined development project or mining operation has been confirmed.
F2	Feasibility of extraction by a defined development project or mining operation is subject to further evaluation.
F3	Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data.
F4	No development project or mining operation has been identified.
G-AXIS: DEGREE OF CONFIDENCE	
G1	Quantities associated with a known deposit that can be estimated with a high level of confidence.
G2	Quantities associated with a known deposit that can be estimated with a moderate level of confidence.
G3	Quantities associated with a known deposit that can be estimated with a low level of confidence.
G4	Estimated quantities associated with a potential deposit, based primarily on indirect evidence.

Abbreviations

AGCE African Geothermal Center of Excellence

AGEA Australian Geothermal Energy Association

ESMAP Energy Sector Management Program of the World Bank Group

CanGEA Canadian Geothermal Energy Association

GEA Geothermal Energy Association

GGA Global Geothermal Alliance

GSE Geological Survey of Ethiopia

IGA International Geothermal Association

INAGA Indonesian Geothermal Association

IRENA International Renewable Energy Agency

ISO International Organization for Standardisation

ITB Bandung Institute of Technology (Institut Teknologi Bandung), Indonesia

OECS Organisation of Eastern Caribbean States

PLN State Electricity Company (Perusahaan Listrik Negara), Indonesia

SDG Sustainable Development Goal

SEEA System of Environmental–Economic Accounting

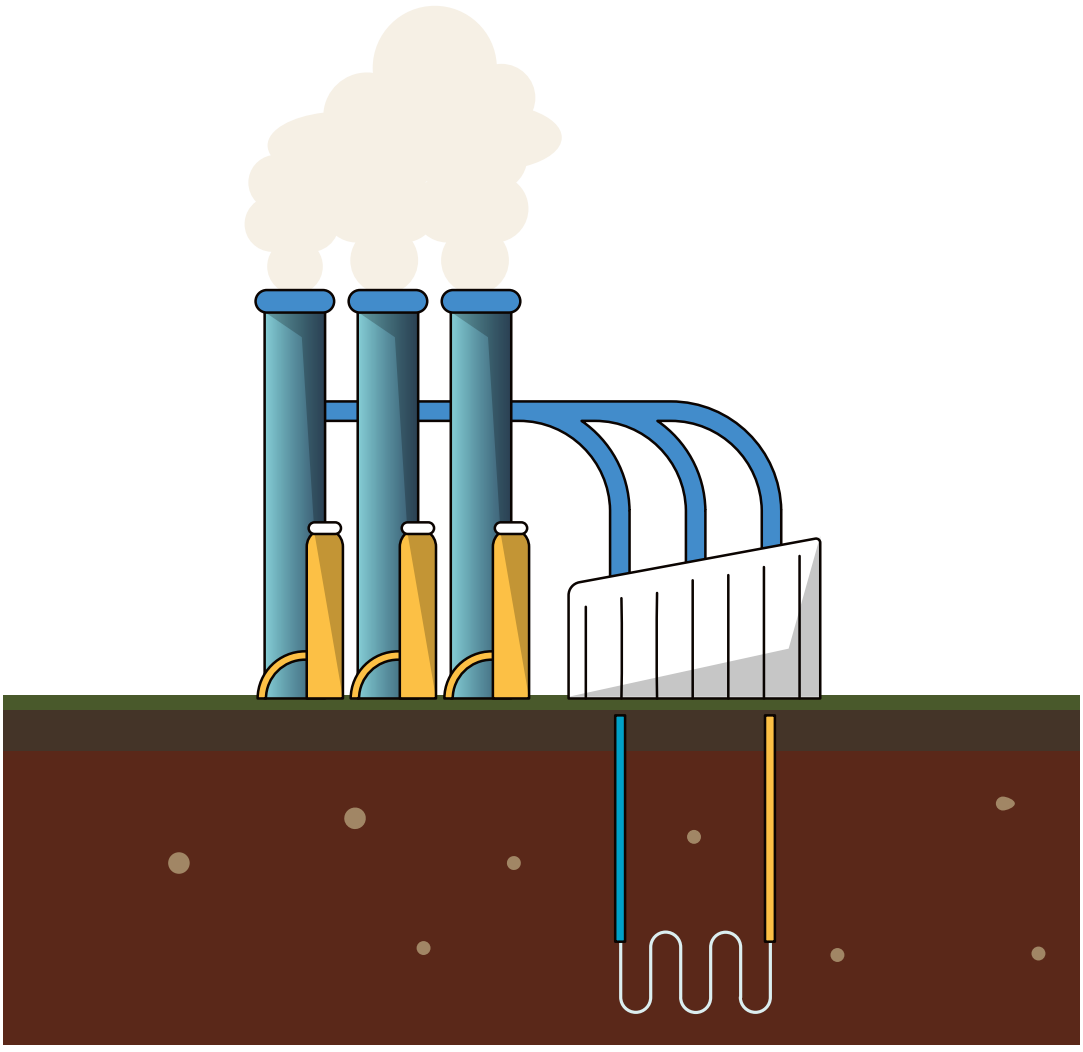
UNECE United Nations Economic Commission for Europe

UNFC United Nations Framework Classification for Fossil Energy and Mineral Resources

UNFC-2009
United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009

UN ECOSOC
United Nations Economic and Social Council

WBG World Bank Group



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