



UNECE



Specifications
for the application of the
United Nations Framework Classification
for Fossil Energy and Mineral Reserves
and Resources 2009 (UNFC-2009)
to
Geothermal Energy Resources

Done in Geneva on 30 September 2016

Specifications for the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) to Geothermal Energy Resources

Document prepared by the Geothermal Working Group*

Summary

This document provides the specifications for the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) incorporating Specifications for its application to geothermal resources. The intended use of this document is in conjunction with UNFC-2009 and the Specifications for the Application of UNFC-2009 to Renewable Energy Resources (Renewables Specifications). The Renewables Specifications represent ‘rules of application’ of UNFC-2009 to Renewable Energy Resources, while this document represents ‘rules of application’ of UNFC-2009 to Geothermal Energy Resources, via the Renewables Specifications. Growing awareness and interest in renewable energy resources, including geothermal energy resources, has highlighted a need to normalize the way in which renewable energy potential is reported. With no globally agreed geothermal standards, guidelines or codes existing prior to the development of this document, it is hoped that the inclusion of geothermal energy within UNFC-2009 will facilitate the improvement of global communication in the geothermal sector as part of the larger energy sector.

* The geothermal specifications were developed by the Geothermal Working Group. Following review by the Expert Group on Resource Classification at its seventh session, 26–29 April 2016, the draft specifications were issued for public comment from 6 June 2016 to 4 August 2016. Development of these specifications has followed the Document Approval Procedure agreed by the Expert Group at its fifth session, April 2014. The geothermal specifications were endorsed by the UNECE Committee on Sustainable Energy at its twenty-fifth session, Geneva, 30 September 2016.

Preface

At the fifth session of the Expert Group on Resource Classification in April 2014, the Task Force on Application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) incorporating Specifications for its Application (as set out in United Nations Economic Commission for Europe (ECE) Energy Series No. 42, ECE/ENERGY/94) to Renewable Energy was requested to provide at least one draft renewable commodity-specific specification for review at the sixth session. To this end, the Task Force called upon the expertise of the International Geothermal Association (IGA) to provide specifications for the application of UNFC-2009 to geothermal energy resources using the full granularity of UNFC-2009.

Through a Memorandum of Understanding¹ that was signed in September 2014, the UNECE and IGA agreed that their goals in the area of geothermal resources were mutually supportive. It was also agreed that the IGA represented the best platform and international umbrella to develop specifications and guidelines for the application of UNFC-2009 to geothermal energy, and to maintain evergreen the texts in a manner consistent with their proper application through regular and periodic review, under the aegis of the EGRC.

Following the Memorandum of Understanding, on 15 October 2014, IGA issued a call for volunteers interested in joining a Working Group to draft the geothermal specifications for the UNFC-2009. A twelve member Working Group was appointed on 15 January 2015.

The Geothermal Working Group developed a set of draft specifications for the application of UNFC-2009 to geothermal energy resources which were presented to the Expert Group on Resource Classification at its seventh session, 26–29 April 2016, for review (document ECE/ENERGY/GE.3/2016/6). The Expert Group requested that the draft specifications be issued for public comment, following which the document approval procedure agreed at the fifth session of the Expert Group should be followed (ECE/ENERGY/GE.3/2014/2, paragraph 97). The draft specifications were issued for public comment on the ECE website from 6 June 2016 – 4 August 2016. The Geothermal Working Group reviewed all the comments received and produced this revised set of specifications in response.

Growing awareness and interest in renewable energy resources, including geothermal resources, has highlighted a need to normalize the way in which renewable energy potential is reported. The renewable energy industry has become a fully commercialized sector, in which several oil and gas majors have already started to play a significant role. These players have voiced a need for a common platform to assess and compare in a transparent way the potential of their renewable and non-renewable energy portfolios. A common assessment and comparison framework for renewable and non-renewable energy resources is also needed by investors, regulators, governments and consumers as a foundation for a comprehensive overview of current and future energy sustainability scenarios at project, company, country, region or world level. With no globally agreed geothermal standards, guidelines or codes existing prior to the development of this document, it is hoped that the inclusion of geothermal energy within UNFC-2009 will facilitate the improvement of global communication in the geothermal sector as part of the larger energy sector.

¹ http://www.unece.org/fileadmin/DAM/oes/MOU/2014/MoU-UNECE_IGA.pdf

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Further acknowledgements go to the Technical Advisory Group of the Expert Group on Resource Classification and to James Ross for their input in addressing technical issues that emerged during the activities of the Working Group.

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I. Introduction

1. The purpose of this document is to enable the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) incorporating Specifications for its Application (as set out in ECE Energy Series No. 42, ECE/ENERGY/94) to Geothermal Resources.
2. The intended use of this document is in conjunction with UNFC-2009 incorporating Specifications for its Application (as set out in ECE Energy Series No. 42, ECE/ENERGY/94) and the Specifications for the Application of UNFC-2009 to Renewable Energy Resources (Renewables Specifications).
3. The Renewables Specifications represent ‘rules of application’ of UNFC-2009 to Renewable Energy Resources, while this document represents ‘rules of application’ of UNFC-2009 to Geothermal Energy Resources, via the Renewables Specifications.
4. Hence, this document is to be used only in conjunction with the two documents mentioned above, and not as a stand-alone document.
5. Text that has been kept unaltered from UNFC-2009 incorporating Specifications for its Application and/or the Renewables Specifications is indicated in this document in italics for clarity.

A. Geothermal Energy Source, Products and Resources

6. In the geothermal energy context, the Renewable Energy Source is the thermal energy contained in a body of rock, sediment and/or soil, including any contained fluids, which is available for extraction and conversion into energy products. This source is termed the **Geothermal Energy Source**, and is equivalent to the terms ‘deposit’ or ‘accumulation’ used for solid minerals and fossil fuels. The Geothermal Energy Source results from any influx to outflux from or internal generation of energy within the system over a specified period of time.
7. A **Geothermal Energy Product** is an energy commodity that is saleable in an established market. Examples of **Geothermal Energy Products** are electricity and heat. Other products, such as inorganic materials (e.g. silica, lithium, manganese, zinc, sulphur), gases or water extracted from the Geothermal Energy Source in the same extraction process do not qualify as Geothermal Energy Products. However, where these other products are sold, the revenue streams should be included in any economic evaluation.
8. **Geothermal Energy Resources** are the cumulative quantities of Geothermal Energy Products that will be extracted from the Geothermal Energy Source, from the Effective Date of the evaluation forward (till the end of the Project Lifetime/Limit), measured or evaluated at the Reference Point.

B. Corporate versus National Resource Reporting

9. UNFC-2009 is geared toward classifying the resources associated with *single* projects. For reporting of corporate or national Geothermal Energy Resources, the estimated quantities of the ‘*single*’ projects may need to be aggregated.
10. UNFC-2009, Part II, section IV and section VI.K provide guidance on the issues of national resource reporting and aggregation of estimated quantities.
11. For national resource reporting, the aggregation of known projects from commercial, non-commercial and/or governmental organizations may not cover the total national

Geothermal Energy Resources. The creation of notional or hypothetical ‘standard’ projects (with associated reference point) may allow an estimate and classification of all the nation’s Geothermal Energy Resources, including those not yet linked to defined projects. These notional projects could be adequately classified as e.g. E3, F3.3, G4.

C. Project and Reference Point Definition

12. The resource classification process consists of defining a Project, or Projects, associated with a Geothermal Energy Source, estimating the quantities of energy that can be recovered and delivered as Geothermal Energy Products by each Project, including any regenerative potential, and classifying the Geothermal Energy Resource based on the criteria defined by the E, F and G categories.

13. The Project is the link between the Geothermal Energy Source and quantities of Geothermal Energy Products and provides the basis for economic evaluation and decision-making. In the context of geothermal energy, the Project includes all the systems and equipment connecting the Geothermal Energy Source to the Reference Point(s) where the final Geothermal Energy Products are sold, used, transferred or disposed of. The Project shall include all equipment and systems required for extraction and/or conversion of energy, including, for example, production and injection wells, ground or surface heat exchangers, connecting pipework, energy conversion systems, and any necessary ancillary equipment. In the early stages of evaluation, a Project might be defined only in conceptual terms, whereas more mature Projects will be defined in significant detail.

14. The Reference Point is a defined location in the production chain where the quantities of Geothermal Energy Product are measured or assessed. The Reference Point is typically the point of sale to third parties or where custody is transferred to the entity’s downstream operations. Sales or production of Geothermal Energy Products are normally measured and reported in terms of estimates of remaining quantities crossing this point from the Effective Date of the evaluation.

15. Where a project produces multiple Geothermal Energy Products, there may be different Reference Points for each product stream (see Section H).

16. Depending upon the specific Project, it could be necessary to report other additional quantities affecting the overall energy conversion process. For instance, in Ground Sourced Heat Pumps, both heat transfer at the evaporator/condenser section and driven energy at the compressor unit should be declared. Other examples concern those systems in which the geothermal apparatus works together with other energy sources (i.e. back-up technologies) or thermal cascading systems. In all these cases, additional points of evaluation may be necessary to provide a clear description of project operation. In general, any reported energy quantity shall be disclosed together with a clear description/definition of the corresponding point of evaluation.

17. The Reference Point may be defined by relevant accounting regulations in order to ensure that the Reference Point is the same for both the measurement of reported sales quantities and for the accounting treatment of sales revenues. This ensures that sales quantities are stated according to their delivery specifications at a defined price.

D. Project Lifetime/Limit

18. The estimated Geothermal Energy Resources for a Project shall be limited to quantities that will be produced during the Project Lifetime.

19. The Project Lifetime will be the minimum of the economic limit, design life, contract period and entitlement period, as defined below. Because of its importance in estimating energy quantities, the Project Lifetime and its basis shall be disclosed in association with any reported quantities.

20. The 'economic limit' is defined as the time at which the Project reaches a point beyond which the subsequent cumulative discounted net operating cash flows from the Project would be negative. For a geothermal project, the economic limit may be the time when the expected extraction rate declines to a level that makes the Project uneconomic, or when it is uneconomic to invest in further extraction infrastructure such as additional wells.

21. The 'design life' of a Project is the expected operating life of major physical infrastructure as defined during the technical and economic assessment of the Project. The replacement of significant project components will constitute a new Project and a new evaluation and estimation of Geothermal Energy Resources shall be performed.

22. The 'contract period' for a geothermal Project is the term of all existing, or reasonably expected, sales contracts for the Geothermal Energy Products. The contract period should not include contract extensions unless there is reasonable expectation of such extensions, based upon historical treatment of similar contracts.

23. Entitlement defines the quantities that accrue to project participants. The 'entitlement period' is the term of all licences and permits which provide rights to access the Geothermal Energy Source, extract the Geothermal Energy Resources and deliver the Geothermal Energy Products into the market. The entitlement period should not include licence extensions unless there is reasonable expectation of obtaining such extensions, based upon historical treatment of similar licences issued by the issuing authority.

24. The Geothermal Energy Source may be expected to last much longer than the Project Lifetime, but any future extracted quantities beyond those estimated for the Project would be assessed and classified as subsequent or additional Projects.

E. Access to Source

25. A reporting entity gains and secures access to a Geothermal Energy Source through licences and permits, or other similar contracts, generally issued by the applicable government authorities. These licences and permits typically allow the entity, subject to applicable regulations, to explore the Geothermal Energy Source and, where appropriate, to develop and operate a Project or Projects to deliver Geothermal Energy Products into the market.

F. Access to Market

26. A geothermal Project gains access to an energy market through the application of processes and technologies, the development of needed infrastructure and policy settings that provide support and opportunity for financial reward through the subsequent sale of the Geothermal Energy Product(s) to target markets and stakeholders. Market access may or may not be supported by entitlements of the Geothermal Energy Product(s) to relevant tariff and non-tariff measures, incentives and certifications as set by the country's governing bodies.

G. Intermittent or Variable Extraction

27. When estimating Geothermal Energy Resources associated with a Project, future production scenarios are assumed (either explicitly or implicitly). Such scenarios describe

expected ‘yearly load hours’ and anticipated production rates, and should include operational and maintenance downtime. Depending on the market or the nature of the off-take of the Geothermal Energy Product(s), the Project may deliver at a constant base rate or with periodical variation between no (or minimum) production and maximum production, for example, the seasonal delivery of heat to a district heating system.

28. Assumed future production scenarios are generally based on estimated future annual energy production rates. These should include the seasonal swing in energy production and load hours. Taking into account the expected (seasonal) variability of future production within a given year, it is possible to report the cumulative energy produced in the subsequent reported years.

29. Reduced or halted production due to a force majeure event (e.g. typhoon, landslide, flooding, earthquake, volcanic eruption) or unexpected operational issues are generally not included in the production forecast. If production is halted for an extended period of time (>1 year) then the classification of the Geothermal Energy Resources should be reviewed and a resource report prepared which discusses and explains the likelihood of restarting production.

H. Projects with Multiple Energy Products

30. Where a Project produces more than one Geothermal Energy Product (e.g. heat and electricity), the Geothermal Energy Resources for each shall be estimated and classified separately, but included in a single report for the Project. The same information shall be declared for each reported quantity, including the type of Geothermal Energy Product and its Reference Point.

31. When a Project requires significant input energy fluxes (e.g. electrical energy to drive heat pump compressors or well production/injection pumps), these quantities should be estimated and reported along with, but separately to, the Geothermal Energy Resources. Any Geothermal Energy that is consumed within the Project upstream of the Reference Point may be explicitly captured as separate but related quantities (with a different Reference Point) and reported as E3.1 (quantities that are forecast to be extracted, but which will not be available for sale).

I. E-Axis Categories

32. [At the time of writing of these specifications, a guidance note on accommodating environmental and social considerations in UNFC-2009 is being developed by the E axis Sub-group of the Expert Group on Resource Classification.]

I.1 Considerations for use of “Foreseeable Future”

33. In the geothermal context, the Foreseeable Future is within a maximum of five years.

I.2. Treatment of Policy Support

34. It is recognized that:

- A variety of policy support mechanisms, regulatory instruments and financial incentives (e.g., feed-in tariffs, premiums, grants, tax credits etc.) exist worldwide to reflect the value that offtakers or the state place on renewable energy (or geothermal energy specifically);
- Some energy subsidies may be available on a project-by-project basis, while others may be available to all such renewable/geothermal energy projects in the market;

- Energy subsidies are typically phased out over time, or once the qualifying renewable energy sources reach a certain share of overall energy production.

35. Thus, when using the subcategory E1.2, the type of *government subsidies and/or other considerations* that make extraction and sale viable shall be disclosed, together with their anticipated future availability as at the Effective Date.

J. F-Axis Categories

J.1. Distinction between and considerations for F1, F2 and F3

36. A Geothermal Energy Resource associated with an Exploration Project (as defined in UNFC-2009, Part II, Annex I) shall be classified as F3. The F3 category has three sub-categories (see UNFC-2009 Part II, section VI. R). The F3.3 sub-category relates to “the earliest stages of exploration activities.” These can include notional estimates of Geothermal Energy Resources for national resource reporting (see section B above).

37. If the result of the first test well is ‘dry,’ ‘unsuccessful,’ or ‘inconclusive,’ the Geothermal Energy Resource estimate shall still be classified as F3, despite the presence of at least one exploration well.

38. Note that, by definition, energy estimates associated with Exploration Projects are also classified as G4 under the ‘G’ category (see section K).

39. No particular considerations apply to F1 and F2 in the geothermal context.

J.2. Treatment of Technology Developments

40. Classification of projects on the F-axis is often dependent upon ‘technology under development.’ Such projects should be classified on the F-axis as F4 unless:

- (i) the technology has been demonstrated to be technically viable in analogous Geothermal Energy Sources; or,
- (ii) the technology has been demonstrated to be technically viable in other Geothermal Energy Sources that are not analogous, and a pilot project is planned to demonstrate viability for this Geothermal Energy Source.

J.3. Additional Quantities in place/ in situ (Category F4)

41. In the context of finite resources, ‘additional quantities in place’ make up the material balance between extracted quantities and total initial quantities in-place. Although a portion of these quantities may become recoverable in the future, as technological development occurs, some or all of these quantities may never be recovered.

42. In the context of geothermal energy, however, the total initial quantity in place is poorly defined because:

- the physical limits of the Geothermal Energy Source, particularly with depth, are poorly defined;
- recharge of the Geothermal Energy Source replaces extracted energy at a rate that is also often poorly defined; and,
- the ‘cut-off parameter’ (e.g. temperature) below which heat extraction is no longer commercially viable is dependent upon the technology used in the Project.

43. There may be situations where it is desirable to report additional quantities in place for a geothermal Project. At such times, by definition, the Reference Point for additional

quantities in place is in situ. The assumed physical limits, the recharge rate and the cut-off parameters for the Geothermal Energy Source shall be stated in any report showing additional quantities in place.

44. Additional quantities in place (F4) should not be reported unless classified using one of the following three F4 sub-categories:

(a) F4.1: the technology necessary to recover some or all of these quantities is currently under active development, following successful pilot studies on other deposits, but has yet to be demonstrated to be technically feasible for the style and nature of deposit in which that commodity or product type is located;

(b) F4.2: the technology necessary to recover some or all of these quantities is currently being researched, but no successful pilot studies have yet been completed;

(c) F4.3: the technology necessary to recover some or all of these quantities is not currently under research or development.

J.4. Definition and Use of F-axis sub-categories

45. See sections J.1 to J.3 for definitions and use of F-axis sub-categories.

K. G-Axis Categories

46. The G-axis categories are intended to reflect all significant uncertainties impacting the estimated Geothermal Energy Resources quantities that are forecast to be extracted by the Project. In order to maintain alignment between different Renewable Energy Resources, as well as with non-renewable fossil energy and mineral reserves and resources, the specifications for the application of the G-axis categories to Geothermal Energy Resources are as in Section I, Confidence levels for G1, G2 and G3 of the Renewables Specifications.

K.1. Known versus Potential Geothermal Energy Sources

47. A Known Geothermal Energy Source is one where one or more wells have established through testing, sampling and/or logging the existence of a significant quantity of potentially recoverable heat. In this context, 'significant' implies that there is evidence of a sufficient quantity of recoverable heat to justify estimation of the Geothermal Energy Resources demonstrated by the well(s) and for evaluating the potential for economic development. 'Recoverable' implies that the depth and the thermal, permeability and fluid properties of the Geothermal Energy Source have been shown, or are expected, to be suitable for recovering heat at rates which have a reasonable chance of being sufficient to support a commercial project.

48. Estimated Geothermal Energy Resources associated with Known Geothermal Energy Sources shall be classified and reported using the 'G' categories, G1, G2 and G3. In the context of a ground sourced heat pump (GSHP) Project, the Geothermal Energy Source shall be considered Known, but associated recoverability and resulting Geothermal Energy Resources have to be evaluated as for other geothermal applications.

49. A Potential Geothermal Energy Source is one where the existence of a significant quantity of recoverable thermal energy has not yet been demonstrated by direct evidence (e.g. drilling and - in some cases - well testing, sampling and/or logging), but is assessed as potentially existing based primarily on evidence from geophysical measurements, geochemical sampling and other surface or airborne measurements or methods. Estimated Geothermal Energy Resources associated with Potential Geothermal Energy Sources shall be classified and reported using the 'G' category G4 or its sub-categories G4.1, G4.2 and G4.3.

K.2. Probability of Discovery for Potential Geothermal Energy Sources

50. For Potential Geothermal Energy Sources reported using the ‘G’ category G4 or its sub-categories G4.1, G4.2 and G4.3, the Probability of Discovery should also be reported.

51. This probability is the chance that further exploration, drilling and well testing will result in the confirmation of a Known Geothermal Energy Source. This will typically be assessed considering the key factors that are required to achieve a discovery which may include temperature, permeability and fluid chemistry or other relevant parameters that are important for the type of energy extraction planned.

52. The quantities reported in the ‘G’ category G4 or its sub-categories G4.1, G4.2 and G4.3 are ‘un-risked’ in that they are the quantities that may be expected to be reported for the project once Known, regardless of the level of Probability of Discovery.

L. Evaluator Qualifications

53. Evaluators shall possess an appropriate level of expertise and relevant experience in the estimation of Geothermal Energy Resources associated with the type of Geothermal Energy Source under evaluation.

54. Relevant national, industry or financial reporting regulations may require an Evaluator to have specific qualifications and/or experience. In addition, regulatory bodies may explicitly mandate the use of a “competent person”, as defined by regulation, with respect to corporate reporting.

55. Any public report detailing Geothermal Energy Resources shall disclose the name of the Evaluator, including qualifications and experience, state whether the Evaluator is an employee of the entity preparing the report, and, if not, name the Evaluator’s employer.

56. Estimation of Geothermal Energy Resources is very commonly a team effort, involving several technical disciplines. It is, however, recommended that only one Evaluator sign the Geothermal Energy Resource report, and that this person be responsible and accountable for the whole of the documentation. It is important in this situation that the Evaluator accepts overall responsibility for a Geothermal Energy Resource estimate and supporting documentation prepared in whole or in part by others, and is satisfied that the work of the other contributors is acceptable.

M. Units and conversion factors

57. Estimated quantities shall be reported in Joule (J) or multiples of the Joule. However, it is recognized that there are traditional measurement units that are widely used and accepted in the geothermal energy sector; such units can therefore be added in parenthesis next to the Joule value.

58. Where applicable, conversion factors (e.g., if quantities are converted from thermal energy to electricity) shall be disclosed.

Annex I

E/F/G Table

<i>Category</i>	<i>Definition</i>	<i>Supporting Explanation (UNFC-2009, Part I, Annex I)</i>	<i>Sub Categories</i>	<i>Definition</i>	<i>Additional Renewable Energy Context</i>	<i>Additional Geothermal Energy Context</i>
E1	<i>Extraction and sale has been confirmed to be economically viable^(a)</i>	<i>Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market conditions. All necessary approvals/ contracts have been confirmed or there are reasonable expectations that all such approvals/contracts will be obtained within a reasonable timeframe. Economic viability is not affected by short-term adverse market conditions provided that longer-term forecasts remain positive.</i>	E1.1	<i>Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market conditions</i>	<i>Extraction is the process of converting a Renewable Energy Source into Renewable Energy Product(s).</i>	<i>In the geothermal context, heat is extracted from the Geothermal Energy Source. In most projects, this heat is carried from the Geothermal Energy Source to the surface via a fluid, typically brine or steam. At surface, the heat may be transferred to another working fluid through heat exchangers and may also be converted into electricity.</i>
			E1.2	<i>Extraction and sale is not economic on the basis of current market conditions and realistic assumptions of future market conditions, but is made viable through government subsidies and/or other considerations.</i>		<i>This includes subsidies needed for present or future operation. If subsidies were used in the past (e.g. to drill a well), they are no longer relevant to the classification of the Geothermal Energy Resource.</i>
E2	<i>Extraction and sale is expected to become economically viable in the foreseeable future.</i>	<i>Extraction and sale has not yet been confirmed to be economic but, on the basis of realistic assumptions of future market conditions, there are reasonable prospects for economic extraction and sale in the foreseeable future.</i>	<i>None</i>	---	---	---

<i>Category</i>	<i>Definition</i>	<i>Supporting Explanation (UNFC-2009, Part I, Annex I)</i>	<i>Sub Categories</i>	<i>Definition</i>	<i>Additional Renewable Energy Context</i>	<i>Additional Geothermal Energy Context</i>
E3	<i>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</i>	<i>On the basis of realistic assumptions of future market conditions, it is currently considered that there are not reasonable prospects for economic extraction and sale in the foreseeable future; or, economic viability of extraction cannot yet be determined due to insufficient information (e.g. during the assessment phase). Also included are quantities that are forecast to be converted, but which will not be available for sale.</i>	E3.1	<i>Quantities that are forecast to be extracted, but which will not be available for sale.</i>	---	For example, quantities produced and used internally (e.g. parasitic use, such as well pumping, power conversion loss, etc.)
			E3.2	<i>Economic viability of extraction cannot yet be determined due to insufficient information (e.g. during the exploration phase)</i>		For example, pre-successful well drilling exploration complete (if a drilled ‘dry’ or unsuccessful, but further drilling is planned, this sub-category is still appropriate). Or, Where there is an active effort to obtain approval, the outcome is unknown or unclarified.
			E3.3	<i>On the basis of realistic assumptions of future market conditions, it is currently considered that there are not reasonable prospects for economic extraction and sale in the foreseeable future.</i>		Uneconomic sites, for example sites far from transmission and/or demand Or Where there is an active effort to obtain approval, the likelihood of receiving approval is low.

^a The phrase “economically viable” encompasses economic (in the narrow sense) plus other relevant “market conditions”, and includes consideration of prices, costs, legal/fiscal framework, environmental, social and all other non-technical factors that could directly impact the viability of a development project.

Category	Definition	Supporting Explanation (UNFC-2009, Part I, Annex I)	Sub Categories	Definition	Additional Renewable Energy Context	Additional Geothermal Energy Context	
F1	<i>Feasibility of extraction by a defined development project or mining operation has been confirmed.</i>	<i>Extraction is currently taking place; or, implementation of the development project is underway; or, sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a development project or mining operation.</i>	F1.1	<i>Extraction is currently taking place.</i>	<i>The term development project is the renewable energy Project as described in Part II.</i>	Successful sustained operation of the Project up to Reference Point. For power projects, this typically includes wells and plant. For direct-use projects, this typically includes the wells, piping and ancillary equipment up to the heat delivery point. For GSHP projects, this typically includes wells or ground heat exchangers, piping, heat pump unit(s) and ancillary equipment up to the user heat delivery point.	Any adverse operational issues (e.g. chemistry, gas content, scaling, corrosion) can be managed.
			F1.2	<i>Capital funds have been committed and implementation of the development project or mining operation is underway.</i>		---	

Category	Definition	Supporting Explanation (UNFC-2009, Part I, Annex I)	Sub Categories	Definition	Additional Renewable Energy Context	Additional Geothermal Energy Context	
			F1.3	<i>Sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development project or mining operation.</i>		---	
F2	<i>Feasibility of extraction by a defined development project or mining operation is subject to further evaluation.</i>	<i>Preliminary studies demonstrate the existence of a project in such form, quality and quantity that the feasibility of extraction by a defined (at least in broad terms) development Project or mining operation can be evaluated. Further data acquisition and/or studies may be required to confirm the feasibility of extraction.</i>	F2.1	<i>Project activities are ongoing to justify development in the foreseeable future.</i>	---	For direct use and electricity projects, at least one well drilled indicating potential for production.	
			F2.2	<i>Project activities are on hold and/or where justification as a commercial development may be subject to significant delay.</i>			
			F2.3	<i>There are no current plans to develop or to acquire additional data at the time due to limited potential.</i>		For GSHP, studies are still ongoing (no drilling needed)	

<i>Category</i>	<i>Definition</i>	<i>Supporting Explanation (UNFC-2009, Part I, Annex I)</i>	<i>Sub Categories</i>	<i>Definition</i>	<i>Additional Renewable Energy Context</i>	<i>Additional Geothermal Energy Context</i>
F3	<i>Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data.</i>	<i>Very preliminary studies (e.g. during the assessment phase), which may be based on a defined (at least in conceptual terms) development project or mining operation, indicate the need for further data acquisition in order to confirm the existence of a project in such form, quality and quantity that the feasibility of production can be evaluated.</i>	F3.1 (*)	<i>Where site-specific geological studies and exploration activities have identified the potential for an individual deposit with sufficient confidence to warrant drilling or testing that is designed to confirm the existence of that deposit in such form, quality and quantity that the feasibility of extraction can be evaluated;</i>	---	Pre-successful well drilling exploration complete (if a drilled well is 'dry' or unsuccessful, but further drilling is planned, this sub-category is still appropriate).
			F3.2 (*)	<i>Where local geological studies and exploration activities indicate the potential for one or more deposits in a specific part of a geological province, but requires more data acquisition and/or evaluation in order to have sufficient confidence to warrant drilling or testing that is designed to confirm the existence of a deposit in such form, quality and quantity that the feasibility of extraction can be evaluated;</i>	---	Pre-drilling exploration in progress
			F3.3 (*)	<i>At the earliest stage of exploration activities, where favourable conditions for the potential discovery of deposits in a geological province may be inferred from regional geological studies.</i>	---	Regional geothermal potential studies

<i>Category</i>	<i>Definition</i>	<i>Supporting Explanation (UNFC-2009, Part I, Annex I)</i>	<i>Sub Categories</i>	<i>Definition</i>	<i>Additional Renewable Energy Context</i>	<i>Additional Geothermal Energy Context</i>
F4	<i>No development project or mining operation has been identified.</i>	<i>In situ (in-place) quantities that will not be produced by any current development project or mining operation.</i>	F4.1	<i>The technology necessary to recover some or all of the these quantities is currently under active development, following successful pilot studies on other deposits, but has yet to be demonstrated to be technically feasible for the style and nature of deposit in which that commodity or product type is located;</i>	<i>Category F4 can be used to classify the currently non-extractable quantities at the geographical location of the defined Project due to, for example, site/area constraints, technology limitations and/or other constraints</i>	---
			F4.2	<i>The technology necessary to recover some or all of the these quantities is currently being researched, but no successful pilot studies have yet been completed;</i>		---
			F4.3	<i>The technology necessary to recover some or all of these quantities is not currently under research or development.</i>		---

Category	Definition	Supporting Explanation (UNFC-2009, Part I, Annex I)	Sub Categories	Definition	Additional Renewable Energy Context	Additional Geothermal Energy Context
G1	<i>Quantities associated with a known deposit that can be estimated with a high level of confidence.</i>	<p><i>For in situ (in-place) quantities, and for recoverable estimates of fossil energy and mineral resources that are extracted as solids, quantities are typically categorized discretely, where each discrete estimate reflects the level of geological knowledge and confidence associated with a specific part of the deposit. The estimates are categorized as G1, G2 and/or G3 as appropriate.</i></p> <p><i>For recoverable estimates of fossil energy and mineral resources that are extracted as fluids, their mobile nature generally precludes assigning recoverable quantities to discrete parts of an accumulation. Recoverable quantities should be evaluated on the basis of the impact of the development scheme on the accumulation as a whole and are usually categorized on the basis of three scenarios or outcomes that are equivalent to G1, G1+G2 and G1+G2+G3.</i></p>	---	<i>High-confidence estimate (low estimate)</i>	<p><i>The G-axis reflects the level of confidence in the potential recoverability of the quantities. Thus, the G-axis categories are intended to reflect all significant uncertainties impacting the estimated Renewable Energy Resources quantities that are forecast to be extracted by the Project and typically would include (but not be limited to) areas such as meteorology, climatology, topography and other branches of geography, ecology and, for geothermal Projects, geology. Uncertainties include both variability in the Renewable Energy Source and the efficiency of the extraction and conversion methodology (where relevant).</i></p> <p><i>Typically, the various uncertainties will combine to provide a full range of possible outcomes, comparable to the extraction of fluids in the petroleum sector. In such cases, categorization should reflect three scenarios or outcomes that are equivalent to G1, G1+G2 and G1+G2+G3.</i></p>	---
G2	<i>Quantities associated with a known deposit that can be estimated with a moderate level of confidence.</i>		---	<i>Moderate-confidence estimate (best estimate) incremental to G1</i>		---

<i>Category</i>	<i>Definition</i>	<i>Supporting Explanation (UNFC-2009, Part I, Annex I)</i>	<i>Sub Categories</i>	<i>Definition</i>	<i>Additional Renewable Energy Context</i>	<i>Additional Geothermal Energy Context</i>
G3	<i>Quantities associated with a known deposit that can be estimated with a low level of confidence.</i>		---	<i>Low-confidence estimate (high estimate) incremental to G2</i>		---

(*) For quantities associated with Exploration Projects.

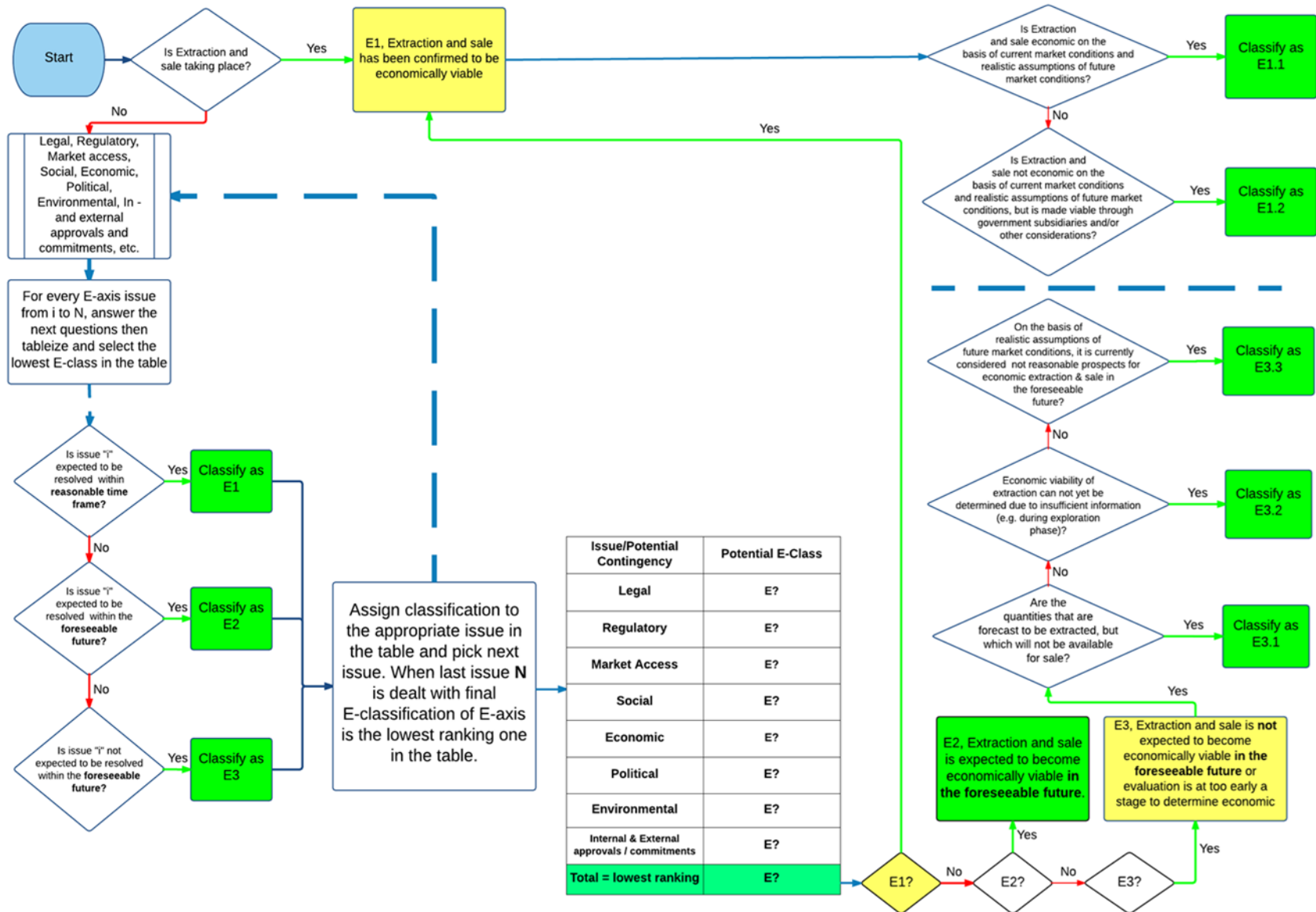
Category	Definition	Supporting Explanation (UNFC-2009, Part I, Annex I)	Sub Categories	Definition	Additional Renewable Energy Context	Additional Geothermal Energy Context
G4	<i>Estimated quantities associated with a potential deposit, based primarily on indirect evidence.</i>	<i>Quantities that are estimated during the exploration phase are subject to a substantial range of uncertainty as well as a major risk that no development project or mining operation may subsequently be implemented to extract the estimated quantities. Where a single estimate is provided, it should be the expected outcome but, where possible, a full range of uncertainty in the size of the potential deposit should be documented (e.g. in the form of a probability distribution). In addition, it is recommended that the chance (probability) that the potential deposit will become a deposit of any commercial significance is also documented.</i>	<i>G4.1</i>	<i>High-confidence estimate (low estimate)</i>	<i>Category G4 is equally applicable to renewable energy, for “Estimated quantities associated with a potential Renewable Energy Source, based primarily on indirect evidence” (e.g. mapping studies).</i>	<i>For example, delineation by surface surveys; evidence, of rock-water interactions, spring analysis, temperature gradient, regional heat-flow maps, etc.</i>
			<i>G4.2</i>	<i>Moderate-confidence estimate (best estimate) incremental to G4.1</i>		
			<i>G4.3</i>	<i>Low-confidence estimate (high estimate) incremental to G4.2)</i>		

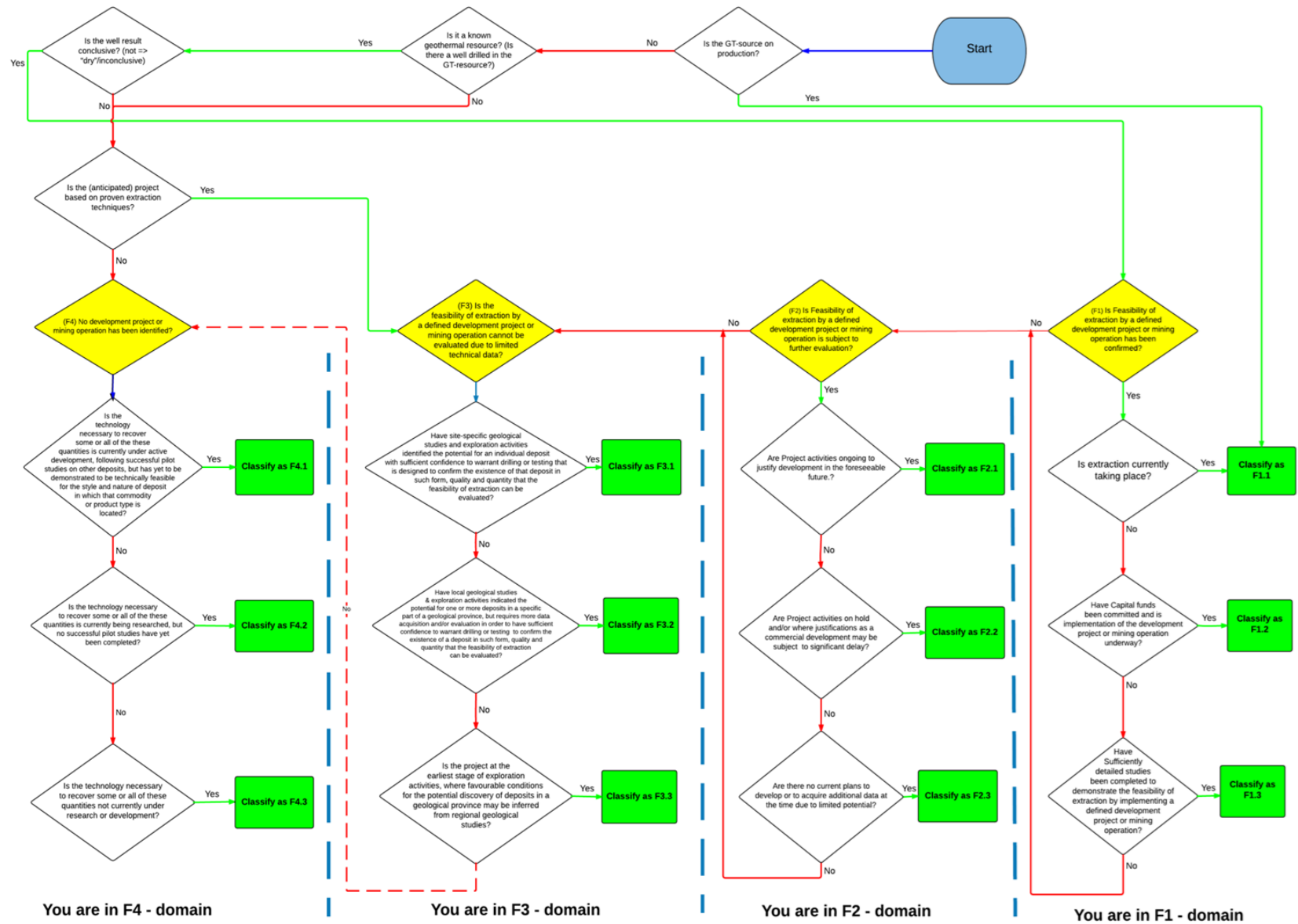
Annex II

Decision tree to aid the classification of geothermal projects according to UNFC-2009

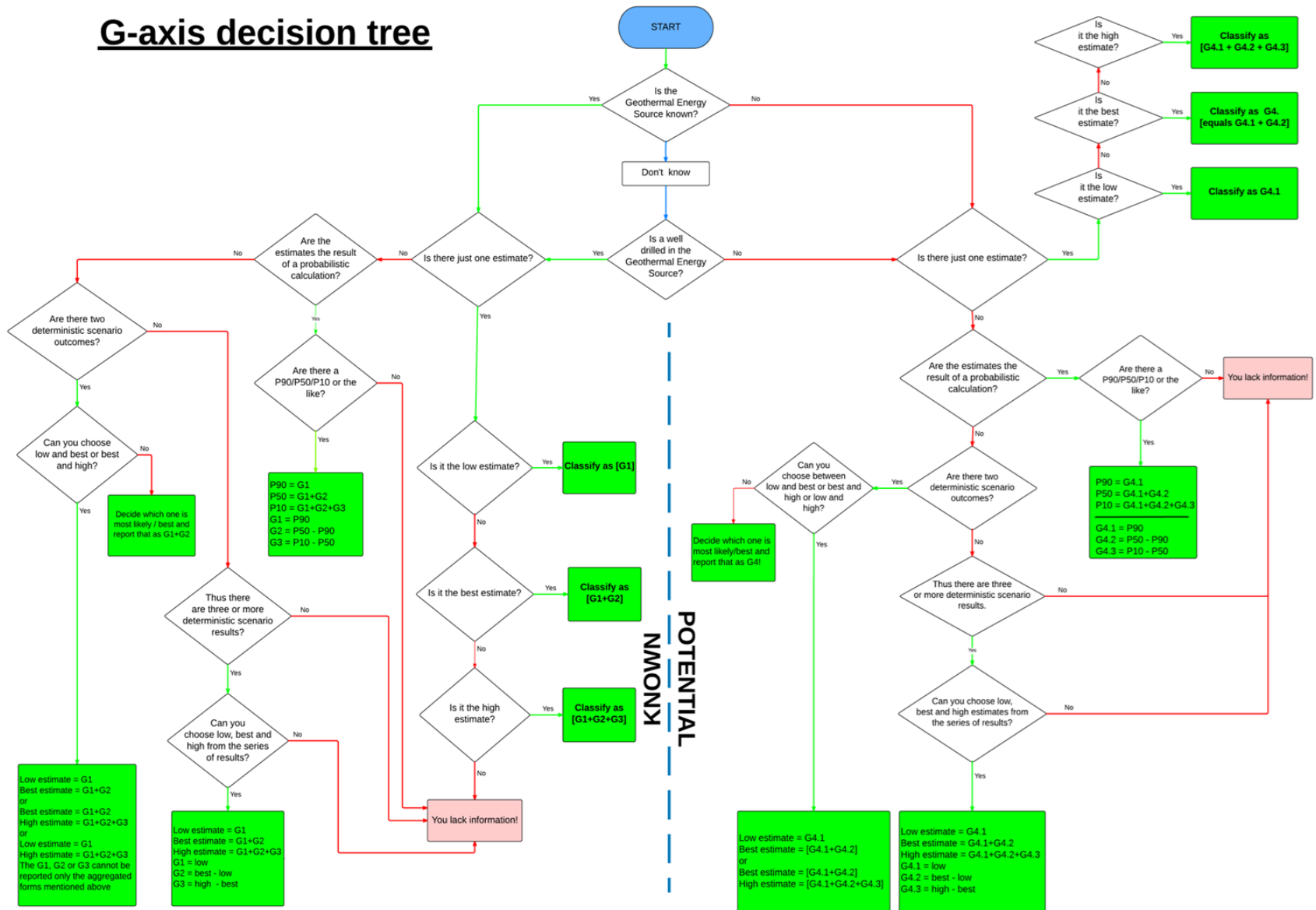
1. The decision tree provided in this document aims to assist with the classification of a geothermal project according to UNFC-2009.
2. For each of the three UNFC-2009 axes (E, F and G), a separate flowchart is provided. By following the arrows from decision box to decision box, the user will end up in a box giving the most suitable classification at the highest hierarchical level for the given axis.
3. "End boxes" have a green colour fill. If staying at the first hierarchical level is desired, then in most cases stopping at the appropriate yellow box is possible. In some cases, a red box means that there may be insufficient information to classify the project.
4. The arrows connecting the boxes are coloured: red represents the direction for decision NO; green represents the direction for decision YES; with a blue arrow, no decision has to be made (passing information only).
5. For the E-axis, a loop is introduced because there is potentially a suite of issues pertaining to the "licence to operate" in the economic, legal, social, etc. domains, which need to be resolved. The lowest ranking E-classification is the one which is to be used for the final classification.
6. Project activities as used in the F-axis classification definitions are related to the technical evaluations that are performed and documented. Investment decisions can be made based on these documented evaluations, or they can serve as support documents to acquire "licences to operate" for the various E-axis domains.

E-axis decision tree





G-axis decision tree



Annex III

Glossary of Terms²

<i>Term</i>	<i>Definition</i>
<i>Aligned System</i>	<i>A classification system that has been aligned with UNFC-2009 as demonstrated by the existence of a Bridging Document that has been endorsed by the Expert Group on Resource Classification.</i>
<i>Bridging Document</i>	<i>A document that explains the relationship between UNFC-2009 and another classification system, including instructions and guidelines on how to classify estimates generated by application of that system using the UNFC-2009 Numerical Codes</i>
<i>Category</i>	<i>Primary basis for classification using each of the three fundamental Criteria of economic and social viability (related Categories being E1, E2, and E3), field Project status and feasibility (related Categories being F1, F2, F3 and F4), and geological knowledge (related Categories being G1, G2, G3 and G4). Definitions of Categories are provided in Annex I to UNFC-2009.</i>
<i>Class(es)</i>	<i>Primary level of resource classification resulting from the combination of a Category from each of the three Criteria (axes).</i>
<i>Complementary texts</i>	<i>Additional texts to provide mandatory requirements (i.e. Specifications) and further guidance regarding the application of UNFC-2009. (This Specifications Document is an example of a complementary text.)</i>
<i>CRIRSCO Template</i>	<i>The CRIRSCO Template of 2013 is the system developed by the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) for solid minerals and, for the purposes of this Specifications Document, includes the reporting codes and standards that are aligned with it.</i>
<i>Criteria</i>	<i>UNFC-2009 utilizes three fundamental Criteria for reserve and resource classification: economic and social viability; field Project status and feasibility; and, geological knowledge. These Criteria are each subdivided into Categories and Sub-categories, which are then combined in the form of Classes or Sub-classes.</i>
<i>Economic Limit</i>	<i>The extraction rate beyond which the remaining cumulative net operating cash flows from the Project are negative, a point in time that defines the Project's economic life. A significant difference with non-renewable energy Projects is that the economic limit will often not be an appropriate basis for the resource assessment because renewable energy is often replenished at an equal or higher rate than consumed and other Project limitations may become relevant before the Economic Limit is reached.</i>
<i>Entitlement</i>	<i>The quantity of Renewable Energy Resource that accrues to a Project's participant.</i>
<i>Evaluator</i>	<i>Person, or persons, performing resource estimation and/or Classification.</i>

² Additional terms are added to the Glossary of Terms included in Annex I of Part II of UNFC-2009 incorporating Specifications for its Application (ECE Energy Series No. 42 and ECE/ENERGY/94) (shown in italics), including the additional terms for the application of UNFC-2009 to Renewable Energy Resources (shown in normal font). The additional terms for the application of UNFC-2009 to Geothermal Energy Resources are shown in underlined font.

<i>Term</i>	<i>Definition</i>
<i>Exploration Project</i>	<i>A Project that is associated with one or more Potential Deposits (as defined below).</i>
<i>Generic Specifications</i>	<i>Specifications (as documented in this Specifications Document) that apply to the classification of quantities of any commodity using UNFC-2009.</i>
<u>Foreseeable Future</u>	<u>In the geothermal context, the Foreseeable Future is within a maximum of five years.</u>
<u>Geothermal Energy Product</u>	<u>A Geothermal Energy Product is an energy commodity that is saleable in an established market. Examples of Geothermal Energy Products are electricity and heat. Other products, such as inorganic materials (e.g silica, lithium, manganese, sulphur, zinc), gases or water extracted from the Geothermal Energy Source in the same extraction process do not qualify as Geothermal Energy Products. However, where these other products are sold, the revenue streams should be included in any economic evaluation.</u>
<u>Geothermal Energy Resources</u>	<u>Geothermal Energy Resources are the cumulative quantities of Geothermal Energy Products that will be extracted from the Geothermal Energy Source, from the Effective Date of the evaluation forward , measured or evaluated at the Reference Point.</u>
<u>Geothermal Energy Source</u>	<u>In the geothermal context, the Renewable Energy Source is the thermal energy contained in a body of rock, sediment and/or soil, including any contained fluids, that is available for extraction and conversion into energy products. This source is termed the Geothermal Energy Source, and is equivalent to the terms 'deposit' or 'accumulation' used for solid minerals and fossil fuels. The Geothermal Energy Source results from any influx to, outflux from or internal generation of energy within the system over a specified period of time.</u>
<i>Known Deposit</i>	<i>A deposit that has been demonstrated to exist by direct evidence. More detailed specifications can be found in relevant commodity-specific Aligned Systems.</i>
<i>Mapping Document</i>	<i>The output of a comparison between another resource classification system and UNFC-2009, or between that system and existing Aligned Systems, which highlights the similarities and differences between the systems. A Mapping Document can provide the basis for assessing the potential for the other system to become an Aligned System through the development of a Bridging Document.</i>
<i>Numerical Code</i>	<i>Numerical designation of each Class or Sub-class of resource quantity as defined by UNFC-2009. Numerical Codes are always quoted in the same sequence (i.e. E;F;G).</i>
<i>Potential Deposit</i>	<i>A deposit that has not yet been demonstrated to exist by direct evidence (e.g. drilling and/or sampling), but is assessed as potentially existing based primarily on indirect evidence (e.g. surface or airborne geophysical measurements). More detailed specifications can be found in relevant commodity-specific Aligned Systems.</i>
<i>PRMS</i>	<i>Petroleum Resources Management System of 2007 (PRMS), which was approved by the Society of Petroleum Engineers (SPE) Board in March 2007 and endorsed by the World Petroleum Council (WPC), the American Association of Petroleum Geologists (AAPG), the Society of Petroleum Evaluation Engineers (SPEE) and the Society of Exploration Geophysicists (SEG).</i>

<i>Term</i>	<i>Definition</i>
<i>Project</i>	<i>A Project is a defined development or mining operation which provides the basis for economic evaluation and decision-making. In the early stages of evaluation, including exploration, the Project might be defined only in conceptual terms, whereas more mature Projects will be defined in significant detail. Where no development or mining operation can currently be defined for all or part of a deposit, based on existing technology or technology currently under development, all quantities associated with that deposit (or part thereof) are classified in Category F4.</i>
<i>Renewable Energy Product</i>	<i>Output from a Renewable Energy Project that is directly linked to (or a direct replacement of) a fungible energy commodity and is saleable in an established market.</i>
<i>Renewable Energy Resources</i>	<i>The cumulative quantities of extractable Renewable Energy Products from the Renewable Energy Source, measured at the Reference Point..</i>
<i>Renewable Energy Source</i>	<i>The primary energy (e.g. sun, wind, biomass, earth thermal energy, river flow, tides, waves) available for extraction of (and conversion into) Renewable Energy Products. The equivalent of the terms “deposit” or “accumulation” used for fossil fuels and solid mineral resources.</i>
<i>Specifications</i>	<i>Additional details (mandatory rules) as to how a resource classification system is to be applied, supplementing the framework definitions of that system. Generic Specifications provided for the UNFC-2009 in this Specifications Document ensure clarity and comparability and are complementary to the commodity-specific requirements included in Aligned Systems, as set out in the relevant Bridging Document.</i>
<i>Specifications Document</i>	<i>Specifications for the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009).</i>
<i>Sub-categories</i>	<i>Optional subdivision of Categories for each of the fundamental Criteria of economic and social viability, field Project status and feasibility, and geological knowledge. Definitions of Subcategories are provided in Annex II to UNFC-2009.</i>
<i>Sub-classes</i>	<i>Optional subdivision of resource classification based on Project maturity principles resulting from the combination of Subcategories. Project maturity sub-classes are discussed further in Annex V of the Specifications Document.</i>
<i>Système International d’Unités</i>	<i>Internationally recognized system of measurement and the modern form of the metric system. Prefixes and units are created and unit definitions are modified through international agreement as the technology of measurement progresses, and as the precision of measurements improves. Abbreviated to SI.</i>
<i>UNFC-2009</i>	<i>United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (ECE Energy series No. 39).</i>