# Specifications

## for the application of the

## United Nations Framework Classification

## for Reserves (UNFC)

## to

## Wind Energy

Done in Geneva on 26 September 2019

# Specifications for the application of the United Nations Framework Classification for Resources to Wind Energy

## Prepared by the Wind Energy Sub-group of the Expert Group on Resource Management


*Summary*

Growing awareness and interest in renewable energy resources, including wind energy resources, has highlighted a need to standardize how renewable energy potential is classified and reported. It is hoped that the inclusion of Wind Energy Specifications within the United Nations Framework Classification for Resources (UNFC) will facilitate appreciation of the potential role that wind energy specifically, and renewable energy in general, must play as part of the larger energy sector. Reporting of wind energy resources in a consistent and comparable manner to other forms of energy will aid with the policy formulation, national and corporate resources management and provide a comparable basis for financing energy projects.

This document provides the specifications for the application of UNFC to Wind Energy Resources (Wind Energy Specifications). Section I of the document provides the necessary context and instructions on how the document should be used. Relevant definitions (section II) and descriptions of key concepts and resource categories (section III) aim to make it clear to the reader and resource estimation professionals how the UNFC framework and the renewable specifications should be applied to wind resources. Generic examples of how wind project resources can be estimated are provided at the end of the document, with corporate, investor and national resource assessments in mind.

These Wind Specifications were approved by the Expert Group on Resource Management at its tenth session, 29 April – 3 May 2019. The Specifications were also made available for public comment for a period of sixty days. They were then endorsed by the United Nations Economic Commission for Europe (ECE) Committee on Sustainable Energy at its twenty-eighth session, 25-27 September 2019.

# Preface

The renewable energy industry has grown significantly in the last few decades, and renewable resources supply almost a fifth of total primary energy demand today. It is very likely that the contribution of renewables at large but especially solar, wind and hydro energy will continue to rise over the coming years. The growth in renewable resources is driven by falling costs, political will and social pressures leading to a more sustainable energy mix in the face of climate change and growing demand for energy globally. The anticipated change in the global energy mix makes it even more important that all energy resources are estimated and categorized consistently at national and international levels.

Work on an international framework classification for reserves and resources started in 1994, with the United Nations International Framework Classification for Reserves/Resources published in 1997. An updated and revised United Nations Framework Classification for Resources (UNFC) was approved by the United Nations Economic Commission for Europe (ECE) Committee on Sustainable Energy in 2013. While UNFC focused initially on depletable energy resources, work has been undertaken to broaden its application to renewable energy.

This work has led to the publication of generic Renewable Energy Specifications for the application of UNFC to renewable energy in 2016, as well as delivering specifications for the application of UNFC to resources from geothermal energy (2016), bioenergy (2017), solar energy (2018) and wind energy (2019).

A group of experts on wind energy resources started work on the Wind Energy Specifications in 2018. This group of experts referred to as the Wind Sub-group and part of the larger Renewables Working Group, was tasked to generate Wind Energy Specifications, utilizing the UNFC and Renewables Specifications. The overall aim of the Wind Sub-group was to generate Specifications that are clear, user-friendly and consistent with other specifications such that the estimation and classification of wind and other renewable energy resources grows and provides a robust basis for comparison of all energy resources.

# Acknowledgements

The Wind Energy Specifications were prepared by a group of experts on a voluntary basis. The members of the Wind Sub-group are: Peter Eecen, Chris Freear, Taylor Geer, Markus Klingbeil (Chair), Tom Lefeber, James F. Manwell, Sathyajith Mathew, Holger Matthiesen, James Primrose, Daran Rife and Görkem Teneler. Particular acknowledgements for their contributions go to Peter Eecen, James F. Manwell and James Primrose.

The Wind Sub-group would like to thank the members of the Technical Advisory Group and the Expert Group on Resource Management for their valuable comments and suggestions as part of their review. The support from the geothermal, bioenergy and solar energy sub-groups is also acknowledged, especially as these groups already provided a valuable starting point via their respective specification documents. The leadership and guidance provided by members of the Renewable Working Group, especially from Frank Denelle, Gioia Falcone and Jeremy Webb, are very much appreciated.

# Contents

# I. Introduction

1. The purpose of this document is to enable the application of the United Nations Framework Classification for Resources (UNFC[1]) and its Specifications to Renewable Energy Resources (Renewable Energy Specification), as set out in ECE Energy Series No. 42, ECE/ENERGY/94, to wind energy resources.

2. The intended use of this document is in conjunction with UNFC and the Renewable Energy Specifications and thus provide the means to estimate wind energy resources using an internationally accepted classification system. As UNFC is a project maturity-based system, a common classification will leverage the effective management of the resources to be put into production over time.

3. The Renewable Energy Specifications represent rules of application of UNFC that are to be applied to all Renewable Energy Resources, while this document represents rules of application of both UNFC and the Renewable Energy Specification to wind energy resources. Hence, this document is to be used only in conjunction with the two documents mentioned above, and not as a stand-alone document. Text that has been kept unaltered from UNFC and the Renewable Energy Specifications is indicated in this document in *italics* for clarity.

4. The Wind Energy Specifications do not provide step-by-step guidance but describe how the principles underpinning UNFC and Renewable Energy Specifications apply to wind energy and what key generic definitions that were originally designed for depletable, non-renewable resources mean in the context of wind energy generation.

5. The Wind Energy Specifications aim to be consistent with other renewable specifications (e.g. solar, bioenergy, geothermal) and this document thus focuses on describing the unique aspects of wind energy as it applies to their estimation and classification per UNFC and the Renewable Energy Specifications. This should allow reporting entities to estimate and classify wind energy resources in a manner that can be compared against the energy resources from other projects as well as energy resources from other fuel sources (e.g. solar, geothermal and/or fossil fuels), using the underlying principle of a project-based assessment.

# II. Wind Energy Definitions

## A. Wind Energy Source, Products and Resources

### 1. Wind

6. Solar radiation and differential heating of the earth's atmosphere and surfaces leads to movement of air within the atmosphere, which is commonly referred to as wind.

### 2. Wind Energy Source

7. The wind energy source (equivalent to the generic term Renewable Energy Source as defined in the Renewable Energy Specifications) is wind. Wind is measured at a given location and height and often expressed as a wind power density. The wind source, which is non-depletable, is documented by wind atlases at a global or regional level.

### 3. Wind Energy Product

8. The wind energy product (equivalent to the generic term Renewable Energy Product as defined in the Renewable Energy Specifications) is the energy commodity that can be sold

[1] The United Nations Framework Classification for Resources (UNFC) changed its name in April 2017. Prior to this, UNFC was known as the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009).

in an established market; the wind energy product is electricity[2], which is generated by a wind energy project.

### 4. Wind Energy Resource

9. The wind energy resource (equivalent to the generic term Renewable Energy Resource as defined in the Renewable Energy Specifications) is the cumulative quantities of wind energy products (electricity) that will be generated from the wind energy source via a project from the effective date of the evaluation forward (until the end of the project lifetime/limit), measured or evaluated at the reference point.

## B. Project and Reference Point Definition

10. In the framework of definitions underpinning UNFC and Renewable Energy Specifications, the wind energy resource estimation and classification process is integrally tied to the definition of a project, or projects, which becomes the basis for both the amount of wind energy resources as well as the class of wind energy resource per the criteria defined by the E, F and G categories in UNFC.

11. It is noted that currently many of the stakeholders in the renewable energy sectors, including wind energy, describe projects in terms of power output, installed power capacity or energy potential rather than a finite amount of energy generated over a given timeframe. This difference in approach, i.e. estimating a production or generation capacity associated with a limitless resource versus the resource generation of a finite, project-based resource, is recognized, and the Wind Energy Specifications do not mean to suggest by applying a project-based estimation approach that the wind energy resource is finite. The project is the link between the wind energy source and quantities of wind energy products and provides the basis for economic evaluation and decision making. In the context of wind energy, the project includes all the systems and equipment connecting the wind energy source to the reference point(s) where the final wind energy products are sold, used, transferred or disposed of. The project shall include all equipment and systems required for the conversion of energy, including, for example, wind turbines, power transmission equipment 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.

12. National wind resource assessments or equivalent (regional) studies are often not project based as projects may not exist yet or it is premature to provide a sufficiently detailed definition of a project. Hence, for national resource reporting, the creation of notional or generic projects (using notional wind product capacities for a given area and a notional project lifetime) may allow an estimate and classification of all the nation's or regional wind energy resources, including those not yet linked to defined projects. These notional projects could be adequately classified as e.g. E3, F3.3, G4.

13. Another key component of the project definition is the identification of the reference point as the point at which the cumulative quantities of wind energy products are measured or estimated, and the quality of the wind energy product follows the appropriate specification. The reference point will typically be either the point of sale to third parties where measurement using appropriately calibrated custody transfer metrology equipment occurs or where custody is transferred. The specific custody transfer point will depend on the legal structure and contract terms of the specific project being evaluated.

## C. Project Lifetime/Limit and Entitlement

14. The estimated wind energy resource for a project is constrained by the lifetime or limits of a project. Generically, the lifetime of a project could be constrained by technical, economic, regulatory or other permit/license cut-offs. As stated in the Renewable Energy

[2] If the wind energy product is another form of energy other than electricity or electric energy, then this shall be clearly stated as part of the wind energy project.

Specifications, *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 normally replenished at an equal or higher rate than consumed, and thus other project limitations, such as the technical (or design) limit or permit limit may become relevant before the economic limit is reached*.

15. Generally, it will be necessary to limit the resources to the defined project lifetime even if the wind source is limitless. This project lifetime has no correlation to the wind source and thus can be determined from the design basis of the facilities or key components of those facilities or based on industry practice or benchmarks for similar projects.

16. Routine maintenance requirements do not constrain the project lifetime as it is likely that wind projects will be maintained as long as it is technically and commercially possible, which could be indefinite. New projects may replace previous projects and thus if significant capital re-investment, requiring a new project investment decision and/or regulatory approval, are required, then the re-investment may constitute a separate, less mature project with its separate resource estimate and classification. As a general guideline, if capital re-investment exceeds 30% of the cost of an equivalent, new project, and requires senior management or regulatory approval, then this re-investment shall be considered a new, separate project.

17. Entitlement defines the quantities of the wind resource that project participants can claim on the basis of their equity share in the project. The reporting entity's entitlement to the wind energy resources may also be limited in time and, if of lesser duration than the design life of the facilities, will be the constraining factor for the entity's wind energy resource estimate, classification and reporting.

18. A reporting entity's entitlement to wind energy resources is governed by applicable contracts. Key elements that provide the basis for the ability of the entity to recognize and report resources are: (i) access to the wind energy source; (ii) exposure to risks in the wind to electricity conversion; and (iii) the opportunity for reward through the subsequent sales of the wind energy product (often referred to as a Power Purchase Agreement, or PPA, or similar).

## D. Access to Source

19. Consistent with the Specifications for the application of UNFC to Renewable Energy Resources, a reporting entity needs to consider the degree of access to the wind energy source, both in terms of quantities available and the level of confidence in accessing those quantities.

20. When using the Specifications for disclosure purposes, the reporting entity shall demonstrate that it has sufficient entitlement to the wind energy source. A reporting entity gains and secures access to a wind energy source through licenses and permits, or other similar contracts, generally issued by the applicable government authorities. These licenses and permits typically allow the reporting entity, subject to applicable regulations, to develop and operate a project or projects to deliver wind energy products into the (electricity) market.

## E. Access to Market

21. Consistent with the Specifications for the application of UNFC to Renewable Energy Resources, a reporting entity must demonstrate that it has:

(a) Sufficient access and entitlement both to the conversion/processing asset to convert the wind energy source to the wind energy product (typically electricity);

(b) The opportunity for a reward through the subsequent sales of the wind energy product;

(c) Sufficient infrastructure and/or logistics with sufficient capacity to transport or otherwise transfer the production to the necessary markets and/or end users for sale either exists or is planned.

22. Access to the market is a key project maturity criterion which will be used in the selection of the appropriate socio-economic viability category (E axis, refer to Table 1).

23. The sufficient access, entitlement and opportunity for reward are typically defined by the selected business and operatorship models. Ownership models are, for example, equity ownership, joint venture (JV) ownership comprising a set of stakeholders, or government ownership; the operator can be any the equity owner, a designated partner in a JV, a government body, an electricity utility or otherwise selected third-party contractor.

24. In case the wind project owner does not own the electricity grid/utility to which the wind energy product is sold, then a Power Purchase Agreement (PPA) or equivalent will be required between the wind project owner and the owner of the electricity utility/grid. A PPA describes the commercial arrangement under which the wind energy product, i.e. electricity, is sold. In combination with the interconnection, the electrical connection between the wind turbines and electricity grid, the PPA provides the means whereby the reporting entity of the wind energy resources accesses the electricity market. The existence of a PPA is another project maturity criterion, which needs to be considered for the appropriate socio-economic viability (E category) assessment.

## F. Intermittent or Variable Generation, including downtime and curtailment

25. An estimate of a wind project's resources will typically require the preparation of a future production forecast/scenario(s) or annual average power output of the delivered electricity and any intermittency/variability shall be appropriately considered within that assessment. Assumptions that impact the overall estimate of cumulative electricity generated from wind energy projects must be made explicit expressed via appropriate confidence limits (G axis) and supported by appropriate evidence (e.g. measurement data, engineering assumptions). This includes:

- estimates for downtime due to planned or unplanned maintenance;
- estimated energy transfer losses;
- loss of grid connection;
- curtailment of the power generated due to electrical grid issues beyond the reference point.

26. If a proportion of electricity that cannot be sold or would be sold at a zero or negative price into the electric grid, then this shall be appropriately factored into the assessment of the economic viability of the wind project and documented accordingly. If technologies such as electricity storage, smart grid and active demand management are part of the project and affect the generation of electricity at the reference point, then these technologies shall be factored into the economic assessment, and any assumptions shall be explicitly stated.

27. Force majeure event (e.g. fire, extreme weather, attacks on an installation), should not generally be considered in the production forecast. However, if such an event does occur, the project classification shall be reviewed considering that event and the potential future implications. An example of this would be the time and actions required to remediate/rebuild the wind project following a force majeure event.

## G. Projects with Multiple Resource Types

28. This aspect is relevant if wind projects are combined with other energy sources, i.e. hybrid projects that combine two or more energy sources to generate more than one type of energy resource.

29. Where a project produces more than one energy product (e.g. heat and electricity), the wind energy resources 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 wind energy product and its reference point.

30. If a wind energy source is used to generate wind energy products which are wholly or partially consumed by the hybrid project, then the wind energy resource shall be categorized accordingly (see section III, E-axis categories).

## H. National versus Corporate Resource Classification and Reporting

31. UNFC is geared towards classifying the energy resources associated with single or multiple projects. For reporting of corporate or national wind energy resources, the estimated quantities of the 'single' projects may need to be aggregated. UNFC, Part II, section IV and section VI.K provide guidance on the issues of national resource reporting and aggregation of estimated quantities.

32. For national resource reporting, the aggregation of known projects from commercial, non-commercial and/or governmental organizations may not cover the total national wind energy resource. This is because national or global resource assessments are often not based on defined projects and estimate a total wind energy potential (expressed as installed power output) rather than finite, project-based wind energy resources (expressed as a fixed energy amount for the project lifetime). The Renewable Specifications define renewable energy sources such as wind as sources that are *replenished at a higher rate than they are consumed.* Additionally, the principles underpinning the UNFC and Renewable Energy Specifications require finite, project-based estimates. The UNFC and Wind Specifications can be used for national, regional or global wind energy resource assessments by taking into consideration the defined projects and defining notional projects with a notional reference point and project duration to estimate the full wind resource. Immature or notional projects and shall be classified accordingly, using the E and F category definitions. If it is assumed that the notional project lifetime will be extended by reinvestment or like-for-like replacements, then such assumptions need to be stated and relevant costs incorporated in the economic analysis. Initial wind projects are likely to be extended or replaced by new projects in their place, often utilizing better technology and generating a larger wind energy resource.

33. If wind energy potentials are used for notional projects, then the associated wind energy resource is the multiplication of the wind energy potential (expressed in installed power or energy delivered per year) and the assumed project duration (years). The uncertainty relating to the potential and thus ultimately wind energy resource shall be assessed using G categories and all assumptions shall be documented.

34. Annex I contains an example (refer to Case 3) of how the UNFC framework can be applied to national resource assessments using notional projects.

# III. Definitions of classes, categories and supporting explanations

35. UNFC is a generic principle-based system in which quantities are classified using three fundamental criteria:

- economic and social viability (E)
- field project status and feasibility (F)
- level of project knowledge and confidence in the potential recoverability of the quantities (G).

36. The key principles are project maturity (as expressed by the E axis and the F axis) and project uncertainty (G axis).

37. Using a numerical coding system, combinations of these criteria create a three-dimensional classification. Categories (e.g., E1, E2, E3) and, in some cases, sub-categories (e.g., E1.1), are defined for each of the three criteria as presented and defined in Annexes I and II of the Generic Specifications. The UNFC sub-classes are defined to provide additional clarity and granularity in using the UNFC framework; however, their use is optional.

38. Additional requirements and explanations are provided below for the application of UNFC to wind energy resources.

## A. E-axis Categories - Establishing Socio-Economic Viability

39. The E axis encompasses all non-technical issues that could directly impact the viability of a project, including energy prices, operating costs, legal, fiscal and regulatory framework, environmental regulations and known environmental or social impediments or barriers.

40. In accordance with the definitions of E1, E2, and E3 as defined in UNFC, economic assumptions shall be based on current market conditions and realistic assumptions of future market conditions; except where constrained by regulation, assumptions of future market conditions should reflect the view of either: (1) the organization responsible for the evaluation; (2) the view of a competent person or evaluator; or, (3) an externally published independent view, which is considered to be a reasonable forecast of future market conditions. All assumptions shall be disclosed.

41. Current market conditions and realistic assumptions of future market conditions should include policy support mechanisms for wind energy but shall not assume that such mechanisms will become more beneficial in the future unless already specified in the regulation.

42. Table 1 provides the definitions of the categories and sub-categories of the E axis and puts the categories in the context of typical wind projects and their potential wind energy resource classification in terms of the social-economic viability. Key terms used in the definitions are explained in the subsequent section.

Table 1
**E-Axis Category Definitions and Application in the Wind Energy Context**

| *Category* | *Definition* | *Supporting Explanation (UNFC, Part I, Annex I)* | *Sub-category* | *Definition UNFC, Part I, Annex II)* | *Additional Wind Energy Context and Requirements* |
|---|---|---|---|---|---|
| E1 | *Extraction and sale has been confirmed to be economically viable* | *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.* | E1.1 | *Extraction and sale is economic on the basis of current market conditions and realistic assumptions of future market condition.* | The generation and sale of electricity via a new or existing wind project is viable, and it can be demonstrated that **all** the following project elements are in place or it is reasonably certain that the elements will be put in place in a reasonable time frame:<br>• Access to source: land lease/ownership of the site (on or offshore) for the project<br>• Access to market: power purchase agreement (or equivalent), whereby the generated electricity can be sold for the project lifetime or until the end of the contract or economic limit has been reached<br>• Authorization/entitlement: permits to build and operate the project<br>• Economic case: the project is economically viable over the project lifetime based on current, anticipated or contractually agreed prices, costs, tax incentives and taxes<br>• Social and environmental considerations: local communities, government agencies and/or non-governmental agencies support the project and there are no counter-indications that pose a risk to the viability of the project. |
| E1 | | | E1.2 | *Extraction and sale is not economic on the basis of current market conditions and realistic assumptions of future market condition, but is made viable through, but is made viable through government subsidies and/or other consideration. government subsidies and/or other consideration.* | In addition to the requirements for E1.1 as listed above, the calculation of economic viability is dependent on regulatory or policy support, typically in the forms of tax and/or price incentives. This includes any regulatory support and/or grants or subsidies needed to make the current project economically viable. Policy support mechanisms are typically phased out over time and the economic case shall reflect this. Support shall not be assumed to become more beneficial in the future unless already so specified in the regulations. |

| *Category* | *Definition* | *Supporting Explanation (UNFC, Part I, Annex I)* | *Sub-category* | *Definition UNFC, Part I, Annex II)* | *Additional Wind Energy Context and Requirements* |
|---|---|---|---|---|---|
| E2 | *Extraction and sale is expected to become economically viable in the foreseeable future.* | *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.* | none | | One or more of the project elements are <u>not</u> yet in place but the missing elements are expected to be in place in the foreseeable future.<br>• Access to source: land lease/ownership of the site for the project lifetime<br>• Access to market: power purchase agreement (or equivalent contract) with suitable buyers(s) have been negotiated or terms defined<br>• Authorization/entitlement: permits to build and operate the project have been identified, the applications process and timelines is clear, or the process may have started.<br>• Economic case: the project is economically viable over the expected project lifetime using anticipated prices, costs, tax incentives and taxes.<br>• Social and environmental considerations: issues relating to local communities, government agencies and/or non-governmental agencies who may oppose the project have been identified, a mitigation and stakeholder engagement plan is in place, thereby making any potential risks manageable. |
| 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.* | *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.* | E3.1 | *Quantities that are forecast to be extracted, but which will not be available for sale.* | If a wind project generates electricity that is consumed entirely by the project for own use, i.e. not sold to electricity buyers. Such a project may be hybrid project, which utilizes two (or more) energy sources (e.g. a combined wind-solar project) and the wind energy resource is consumed by machines that are required for the extraction of the other energy source. |

| *Category* | *Definition* | *Supporting Explanation (UNFC, Part I, Annex I)* | *Sub-category* | *Definition UNFC, Part I, Annex II)* | *Additional Wind Energy Context and Requirements* |
|---|---|---|---|---|---|
| E3 | | | E3.2 | *Economic viability of extraction cannot yet be determined due to insufficient information (e.g., during the exploration phase).* | The project is not viable because one or more of the project elements are insufficiently defined and/or inadequately assessed due to insufficient information.<br>• Access to source: land lease/ownership requirements for the project site are not known, unlikely to be obtained and/or the timeframe to obtain access to the source not known. The wind source assessment is insufficient or not available, and wind source data needs to be obtained. Regulatory requirements may not be known.<br>• Access to market: the required power purchase agreement (or equivalent contract) with suitable buyers(s) have not been identified and/or terms have not been negotiated with buyers.<br>• Authorization/entitlement: required permits to build and operate the project are not known or unlikely to be obtained in the foreseeable future<br>• Economic case: the project is economically not viable or viability cannot be assessed due to lack of knowledge of likely prices and costs over the project lifetime<br>• Social and environmental considerations: issues relating to local communities, government agencies, non-governmental agencies who may oppose the project have not been identified and the extent of managing social and environmental risks to the project is not known. |
| | | | E3.3 | *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.* | The project is not viable because it is likely that one or more of the project elements (e.g. access to source and/or market, entitlement) will not be in place or obtainable. |

43. Definitions of key terms used for the E axis:

(a) **Reasonable Expectations and Reasonable Prospects:** It is deemed likely that contracts, leases, permits, sales agreements and social (community, government or NGO support) to access the wind energy source and access the wind product market will be obtained for the wind project. The likelihood of obtaining the abovementioned project requirements can be demonstrated on the basis that necessary applications or legal processes have commenced, or a documented track record exists, enabling the reporting entity to show that the project requirements have been met before under similar project conditions and in the same regulatory and social environment. Relevant assumptions, track records and/or precedents shall be documented and disclosed;

(b) **Reasonable Timeframe and Foreseeable Future:** A period of five years or less is deemed a "reasonable timeframe" and "foreseeable future" but this period can be longer than five years, if special circumstances exist, and should be justified by the competent person or evaluator. Such special circumstances could arise from, e.g. lengthy regulatory/environmental approval times, deferred economic incentives or long project development phase. The justification for recognizing wind energy resources when the timeframe exceeds five years shall be provided by the reporting entity;

(c) **Economic Viability:** Economic viability is defined by the project reaching a positive cumulative cash flow using the expected generated quantities of electricity, the contracted (current or anticipated) commodity prices, capital investment, operating, decommissioning and restoration costs, royalties (if applicable), tax or financial incentives. The economic viability shall be demonstrated for the project lifetime, which is determined by the entitlement (or expectation thereof), the economic limit[3] (the point at which the positive cumulative cash flow starts to decrease, or operating costs are greater than revenue) or the technical limit (i.e. lifespan of the installation and wind turbines). The economic viability shall be demonstrated at the reference point, which is typically the sales point for the wind energy product. If the reporting entity uses a scenario or probabilistic approach to calculate economic viability, the most likely scenario, best estimate or P50 case shall be used for the demonstration of economic viability.

## B. F-axis Categories – Establishing Field Project Status and Feasibility

44. The F axis addresses the maturity of the wind project and how the project maturity affects the classification of the wind energy resource. The assessment of maturity covers both the technical feasibility of the project and the level of commitment of the project owners/sponsors to proceed with the project and its subsequent maturation until an investment decision to build and operate the project is taken. A development plan ultimately needs to be defined for a wind project, and the maturity of this plan is reflected in the appropriate F-axis category. Regulatory requirements (e.g. environmental studies, feasibility studies, economic evaluations, operational competencies) may exist which mandate a development plan of a certain maturity for the governing body to issue permits to execute the project.

45. An F1 wind project may be in operation, approved for development, or at the stage at which sufficient information has been aggregated to confirm the technical feasibility of a fully defined wind project. Generally, F1 projects are sufficiently mature and thus do not require further significant technical refinements prior to commitment of capital funds, or the project sponsor does not require any further technical studies prior to the decision to commit capital.

46. F2 projects are still in the development phase and require further technical definition prior to a decision to commit capital funds. Studies are underway to evaluate the feasibility of the project, and further work may be necessary on wind energy source availability to sufficiently define the project for sanction. F2 includes wind projects with pending

[3] Many renewable projects do not reach such a point and keep on generating positive cashflow as the source is limitless.

development or development on hold given the current state of technology or due to limited potential the project is currently not viable.

47. F3 projects do not have sufficient information to quantify the wind energy product that may be generated. F3 projects are those projects where insufficient information is available to evaluate the quantity of electricity that can be generated, and further study is necessary prior to development of the wind project.

48. F4 projects are generally used to estimate wind energy resources that are not yet defined by a project but can be generated on the basis of known wind sources. Known wind sources as described by wind atlases are the equivalent of in situ sources. The F4 estimate of wind energy resources shall be described in time-bounded manner (e.g. 50 or 100 years) and the yearly averaged production or energy generation capacity is chosen as measure for the available wind resource, so that comparable estimates can be made to wind energy resource potentials in other locations where projects are not yet defined. All assumptions (technical, economic, social acceptance and time horizon) used to make the F4 estimate should be clearly stated.

Table 2
**F-axis Category Definitions and Application in the Wind Energy Context**

| Category | Definition | Supporting Explanation (UNFC, Part I, Annex I) | Sub-category | Definition UNFC, Part I, Annex II) | Additional Wind Energy Context and Requirements |
|---|---|---|---|---|---|
| F1 | *Feasibility of extraction by a defined development Project or mining operation has been confirmed.* | *Extraction is currently taking place or, implementation of the development Project or mining operation is underway; or, sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development Project or mining operation.* | F1.1 | *Extraction is currently taking place.* | The wind project is generating power as per the development plan at the reference point and as per the agreed power agreement(s) or equivalent. There are no known hurdles to proceeding with electrical energy generation. |
| | | | F1.2 | *Capital funds have been committed and implementation of the development Project or mining operation is underway.* | The development plan is in place and agreed by all relevant stakeholders in the project. The owners/partners/shareholders of the project have all committed to fund the wind project and proceed with the building of the project or the building of the project has already started. The project is not yet generating electrical energy. |
| | | | F1.3 | *Sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined development Project or mining operation.* | Feasibility studies exist and demonstrate that the project is technically mature, fully defined and can be executed within a reasonable time but funding commitment may not be in place yet.<br>Where the feasibility/maturity status varies across a project, the lowest status shall define the categorization. Sub-categories may be utilized to reflect the level of commitment by the project sponsor/owner. |
| F2 | *Feasibility of extraction by a defined development Project or mining operation is subject to further evaluation.* | *Preliminary studies demonstrate the existence of a deposit 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.* | F2.1 | *Project activities are ongoing to justify development in the Foreseeable Future.* | Work is ongoing to demonstrate that the wind project will be mature/feasible in a reasonable time, i.e. the wind energy source assessment, the wind turbine design/selection and the connection to the power grid (sales point) will occur in the foreseeable future. |

| Category | Definition | Supporting Explanation (UNFC, Part I, Annex I) | Sub-category | Definition UNFC, Part I, Annex II) | Additional Wind Energy Context and Requirements |
|---|---|---|---|---|---|
| | *Feasibility of extraction by a defined development Project or mining operation is subject to further evaluation.* | *Preliminary studies demonstrate the existence of a deposit 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.* | F2.2 | *Project activities are on hold and/or where justification as a commercial development may be subject to significant delay.* | Due to lack of technical information (e.g. wind source, wind farm design and specifications), the project is on hold and will not become a commercial development in the foreseeable future. |
| | | | F2.3 | *There are no current plans to develop or to acquire additional data at the time due to limited potential.* | No further comments. |
| F3 | *Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data.* | *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.* | F3.1 | *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.* | The wind energy source assessment indicates that the source is sufficiently prolific locally that it merits further direct, site-specific, long-term measurements and evaluation. |
| F3 | *Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data.* | *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.* | F3.2 | *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.* | The wind energy source has been evaluated via regional measurements but direct, site-specific measurements and evaluation is required. |

| Category | Definition | Supporting Explanation (UNFC, Part I, Annex I) | Sub-category | Definition UNFC, Part I, Annex II) | Additional Wind Energy Context and Requirements |
|---|---|---|---|---|---|
| | | | F3.3 | *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.* | The wind energy source has not been measured regionally but computer models and general understanding of regional wind patterns suggest that the source should be sufficiently prolific to warrant further evaluation. |
| F4 | *No development project or mining operation has been identified.* | *In situ (in-place) quantities that will not be produced by any current development project or mining operation.* | 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.* | The required generation/conversion technology (e.g. turbine, mast design, novel materials, storage, smart grids) exists and has been trialed in a pilot project but has not been used at this type of location and/or at the scale of the project. |
| F4 | *No development project or mining operation has been identified.* | *In situ (in-place) quantities that will not be produced by any current development project or mining operation.* | 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.* | The wind turbine or generation/conversion technology is in the research stage and has not been piloted/trialed (e.g. floating wind turbines for deep water). |
| | | | F4.3 | *The technology necessary to recover some or all of these quantities is not currently under research or development.* | The wind turbine or generation/conversion technology to develop the wind resource at that location or height is not being researched or developed. |

*Note:* The Wind Sub-group strongly advocates expanding UNFC by adding a subcategory F4.4, by which unidentified or notional projects could be categories on the basis of existing technologies.

## C. G-axis Categories – Delineating Uncertainty

49. In UNFC, the *G axis designates the level of confidence in the geological knowledge and potential recoverability of the quantities*. This definition reflects the fact that, at the time of its publication, UNFC was designed to be applied to fossil energy and mineral reserves and resources. As geological knowledge is not applicable to wind energy resources, the G axis denotes the level of confidence in the potential generation of wind energy resources.

50. *Thus, the G-axis categories are intended to reflect all significant uncertainties impacting the estimated* wind energy resources that are forecast to be produced by the project. Uncertainties include both variability in the wind energy source (seasonal and daily source uncertainty) and the efficiency of the conversion technology to electrical energy, which is sold at the reference point.

51. In general, an uncertainty impacts the quantity of the wind energy resource generated from a project, but not the viability of the project itself. If the impact of an uncertainty is sufficient to affect the viability of the project, then it should be considered as a risk and a lower degree of maturity on either the E axis or F axis should be considered.

52. Within UNFC, there are three established approaches to determining appropriate estimates for G1, G2 and G3:

(a) The "incremental" approach, which is based on estimates for discrete portions of the wind energy source and/or the project, where each estimate is assigned a level of confidence (high, moderate and low);

(b) The "scenario" approach, which is based on three discrete scenarios that are designed to reflect the range of uncertainty in the possible outcomes (low, best, and high estimates) of the project;

(c) The "probabilistic" approach, where multiple possible scenarios are generated (e.g. by Monte Carlo analysis) from input distributions of parameter uncertainty associated with the project. Three specific outcomes (P90, P50 and P10 values) are then selected from the output probability distribution as representative of the range of uncertainty and are equated to low, best (medium) and high estimates, respectively (where P90 means there is 90% probability of exceeding that quantity).

53. Any of the three approaches is permissible and the evaluator shall state which approach is being used. In all cases, due consideration shall be given to possible dependencies between input parameters. Further, whichever approach is used, all three categories (G1, G2 and G3) should be reported to provide an indication of the range of uncertainty in the estimate. Irrespective of the approach, the basis of the uncertainty assessment and all assumptions shall be provided. Where a project's long-term financial or operating plan is being used to provide an estimate of a wind energy resource, then that plan/projection shall typically be considered as a best (medium or P50) estimate, that is, a G1+G2 classification. The G4 category applies mostly to the uncertainty of the wind energy source, where no direct measurements exist to quantify the wind energy product, and the quantification relies on indirect estimates or computational models only.

Table 3
**G-axis Category Definitions and Application in the Wind Energy Context**

| *Category* | *Definition* | *Supporting Explanation (UNFC, Part I, Annex I)* | *Sub-category* | *Definition UNFC, Part I, Annex II)* | *Additional Wind Energy Context and Requirements* |
|---|---|---|---|---|---|
| G1 | *Quantities associated with a known deposit that can be estimated with a high level of confidence.* | *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. 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.*<br><br>*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.* | none | | Incremental method: high confidence (G1)<br>Scenario method: low estimate<br>Probabilistic method: P90 value |
| G2 | *Quantities associated with a known deposit that can be estimated with a moderate level of confidence.* | | | | Incremental method: best confidence (G1+G2)<br>Scenario method: best/medium estimate<br>Probabilistic method: P50 value |
| G3 | *Quantities associated with a known deposit that can be estimated with a low level of confidence.* | | | | Incremental method: low confidence (G1+G2+G3)<br>Scenario method: high estimate<br>Probabilistic method: P10 value |

| *Category* | *Definition* | *Supporting Explanation (UNFC, Part I, Annex I)* | *Sub-category* | *Definition UNFC, Part I, Annex II)* | *Additional Wind Energy Context and Requirements* |
|---|---|---|---|---|---|
| G4 | *Estimated quantities associated with a potential deposit, based primarily on indirect evidence.* | *Quantities that are estimated during the initial assessment 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.* | G4.1 | *High-confidence estimate (low estimate)* | No directly measured data exists<br>Incremental method: high confidence<br>Scenario method: low estimate<br>Probabilistic method: P90 value |
| | | | G4.2 | *Moderate-confidence estimate (best or medium estimate) incremental to G4.1 such that G4.1+G4.2 equates to a best estimate of the quantities.* | No directly measured exists<br>Incremental method: best confidence (G1+G2)<br>Scenario method: best or medium estimate<br>Probabilistic method: P50 value |
| | | | G4.3 | *Low-confidence estimate (high estimate) incremental to G4.2, such that G4.1+G4.2+G4.3 equates to a high estimate of the quantities.* | No directly measured exists<br>Incremental method: low confidence (G1+G2+G3)<br>Scenario method: high estimate<br>Probabilistic method: P10 value |

## D. Adaptation of UNFC Categories and Sub-classes for Wind Energy Projects

54. The categories and sub-classes are listed below in an abbreviated form for ease of reference.

Table 4
**Abbreviated categorization of UNFC for wind projects**

| Category | Socia-economic viability of project | | | | |
|---|---|---|---|---|---|
| **E** | **legal and authorized?** | **economic?** | **social & environmental acceptance?** | **sub-class** | **definition/key characteristics of sub-class** |
| | yes | yes | yes | E1.1 | confirmed viable |
| | yes | potentially | yes | E1.2 | economically viable with government subsidies |
| | likely | | | E2 | reasonable prospects in the foreseeable future |
| | no commercial sale of electricity | | | E3.1 | electrical energy not available for sale; for own use only |
| | unknown | | | E3.2 | insufficient information |
| | not expected | | | E3.3 | no reasonable prospects in foreseeable future |

| Category | Project status and technical feasibility | | | | |
|---|---|---|---|---|---|
| **F** | **defined?** | **feasible?** | **commercial?** | **sub-class** | **definition/key characteristics of sub-class** |
| | yes | yes | yes | F1.1 | exitisting, operating |
| | | | | F1.2 | not operational, funding committed |
| | | | | F1.3 | feasible, no committed funding |
| | yes | potentially | potentially | F2.1 | in plan, further studies required |
| | | | | F2.2 | on hold |
| | | | | F2.3 | no plans to proceed, limited potential |
| | potentially | potentially | potentially | F3.1 | evaluation ongoing, based on limited, insufficient site data |
| | | | | F3.2 | evaluation ongoing, based on regional data; site data required |
| | | | | F3.3 | evaluation ongoing, based on estimates, site data required |
| | no | unknown | unknown | F4.1 | technology exists or in pilot phase |
| | | | | F4.2 | technology in research phase |
| | | | | F4.3 | technology is not being researched |

| Category | Confidence in wind product quantity generated by project | | | | |
|---|---|---|---|---|---|
| **G** | **incremental approach** | **scenario approach** | **probabilistic approach** | **sub-class** | **definition/key characteristics of sub-class** |
| | high | low | P90 | G1/G4.1 | known with direct evidence / potential with indirect evidence |
| | moderate | best | P50 | G2/G4.2 | known with direct evidence / potential with indirect evidence |
| | low | high | P10 | G3/G4.3 | known with direct evidence / potential with indirect evidence |

## E. Evaluator or Competent Person Qualifications

55. Evaluators or Competent Persons are professionals, who are employed and/or contracted by reporting entities to estimate and categorize wind energy resources. *A Competent Person is one who has the ability to put skills, knowledge and experience into practice in order to perform activities or a job in an effective and efficient manner for resource classification, management and reporting.* Evaluators shall possess an appropriate level of expertise and relevant experience in the estimation of quantities associated with the type of wind energy resource(s) under evaluation. It is anticipated that the estimation of wind energy resources will require the input from professionals and/or experts from several technical disciplines. The person or persons may be employees of the entities that have an economic interest in the project or independent consultants contracted for reviews, audits, regional or national resource estimation. In all cases, the entity accepting the evaluation takes

responsibility for the results of the estimation. The relationship between the reporting entity and the evaluators shall be stated.

56. *A Competent Person and disclosure requirements may be governed by a body, regulator or authority in appropriate jurisdictions. The governance may at the national level be a Ministry or a Commission mandated by the Government for this task. For financial reporting, the Stock Exchange Commission or a banking sector regulator may govern these requirements. An individual body such as a company may establish its own governance oversight answerable to an independent Board of Directors, trustees or other stakeholders.*

## F. Units and Conversion Factors

57. In order to facilitate global comparability of resource estimates, it is recommended that the Système International d'Unités (SI units) is used for reporting of resource quantities. The SI unit for energy is Joule (J) or multiples (e.g. GJ, TJ or EJ) of Joule. However, it is recognized that there are traditional measurement units that are widely used and accepted for certain commodities; where such units are used for reporting purposes, conversion factors to SI units shall be provided. Similarly, where quantities are converted from volume or mass to energy equivalents, or other conversions are applied, the conversion factors shall be disclosed.

# Annex I

## Generic Example Cases

58. The objective of the generic example cases is to demonstrate how the wind specification can be applied to a range of projects. The examples are illustrative but based on typical current day assumptions, and the underlying technical and economic evaluations are simplified.

59. Example case 1: Single onshore wind farm with an assumed technical lifespan of 20 years (phase I)

60. Example case 2: Single onshore wind farm from case 1, refurbished for an additional 20 years (phase II)

61. Example case 3: Multiple, generic offshore wind farms as part of a notional National assessment by country ABC

62. These three examples are selected to demonstrate how the wind specifications are applicable for the following reporting purposes:

(a) Corporate reporting - a defined, commercial, mature project that is about to start operations and has committed funding (example case 1) and a less-defined, more immature project without committed funding (example case 2);

(b) National reporting - a series of hypothetical (generic or standard) projects that are not defined, immature and without committed funding (example case 3).

63. The technical, commercial and viability assumptions are described briefly for each case, and the recommended evidence underpinning each assumption is stated. The reasoning leading to the categorization of the resource is also given to illustrate why the selected sub-class is appropriate

Table A.1
**Results for each example case**

| *Example Case:* | *1 – Single onshore wind farm (phase I)* | *2 – Single onshore wind farm (phase II)* | *3 – Multiple Offshore wind farms (multi-phase)* |
|---|---|---|---|
| **Reporting entity:** | Corporation | Corporation | Country ABC (for National reporting) |
| **Sub-class E:** | E1.2 | E3.2 | E3.2 |
| **Sub-class F:** | F1.2 | F2.2 | F3.2 |
| **Sub-class G1 (high confidence)** | 1,183 TJ | 1,261 TJ | 5 EJ |
| **Sub-class G2 (moderate confidence)** | 1,419 TJ | 1,514 TJ | 6 EJ |
| **Sub-class G3 (low confidence)** | 1,892 TJ | 2,018 TJ | 9 EJ |
| **Project limit:** | Technical, 20 years | Technical, 20 years | Technical, 50 years |
| **Effective date:** | 01.01.20XX | 01.01.20XX | 01.01.20XX |
| **Evaluation date:** | July 20XX | July 20XX | July 20XX |
| **Evaluator:** | UNFC Wind Sub-group | UNFC Wind Sub-group | UNFC Wind Sub-group |

## A. Case 1: Single onshore wind farm (phase I)

Table A.2
**Details of Single onshore wind farm (phase I)**

| | |
|---|---|
| Project type: | An onshore wind farm with known wind energy source, located in country ABC, for commercial generation of electricity, which is sold to a local electricity utility company. |
| Project scope: | 10 wind turbines with 800 kW rating per turbine |
| Capital cost (incl. installation): | $600,000/turbine |
| Operating costs per year: | $15,000/year |
| Technical lifespan of turbines: | 20 years |
| Total area leased: | 20 hectares (ha) |
| Royalties: | $2000/ha |
| Electricity price: | $0.04/kWh (excl. government subsidy)<br>(fixed price as per power purchase agreement)<br>$0.07/kWh (incl. government subsidy) |
| Full load factor[4]: | 25% (low estimate, high confidence)<br>30% (best estimate, moderate confidence)<br>40% (high estimate, low confidence) |
| Financing cost of capital: | 25% of capital to be borrowed at 5% interest rate over a 20-year loan period<br>Asset depreciation is linear for the project lifetime |
| Corporate tax rate: | 25% |

| | |
|---|---|
| Wind energy source: | The wind speeds at a given height have been measured over a period of two years. The wind class, as well as daily and seasonal variance (uncertainty) in wind speed, is known. |
| Wind energy product: | Electricity (measured in TJ), sold at the reference point (see below). |
| Wind energy resource: | The total amount of electricity sold over the lifetime of the project, which is 20 years and is determined by the technical lifespan of the wind turbines. |
| Reference point: | The reference point is the electricity sales meter, connecting the wind farm with the electric grid, which is operated by the electric utility company and buyer of the electricity. |
| Project entitlement: | The wind farm developer/operator is a single commercial company with 100% entitlement to the project, its revenues and obligations. The company finances the costs partly through equity and partly through bank loans. The company has taken its final investment decisions, meaning that the company has set aside the required capital via its annual business planning process and the board of the company has formally agreed to the execution of the project. |
| Project timeline: | The installation of the wind farm and associated infrastructure will begin next year. Installation is expected to take one year. |
| Access to Source: | The lease for the land has been secured and signed for 20 years, with the option to renew. The associated royalties have been fixed for 20 years and can be renegotiated after expiry of the 20-year period.<br>The wind farm developer has secured the permits from the local government to build and operate the wind farm for 20 years.<br>There is no local community opposition to the project after an environmental assessment study was completed and submitted for government and public review. |
| Access to Market | The power purchase agreement has been signed for 20 years, specifying the price for the electricity sold. |
| Economic assessment: | The cashflow chart below (expressed in MOD, Money of Day) shows that the project will not reach positive cumulative cashflow over the project lifetime at the agreed sales price unless the government subsidy is applied. The government price subsidy allows the project to become cashflow positive in year 14. The cashflow shown below is undiscounted[5] in nominal terms. |

[a] Load factor is the ratio of annual electrical energy generated and the installed maximum capacity. The load factor depends on the wind class, power curve of the turbine, intermittency of the wind and turbine capacity.

[b] For company-internal financial decision making, companies will apply a discount factor to account for the cost of capital and inflation. This aspect is omitted for the sake of resource estimation, given that the corporate discount factor can vary.

Figure A.I
**Cashflow assessment**

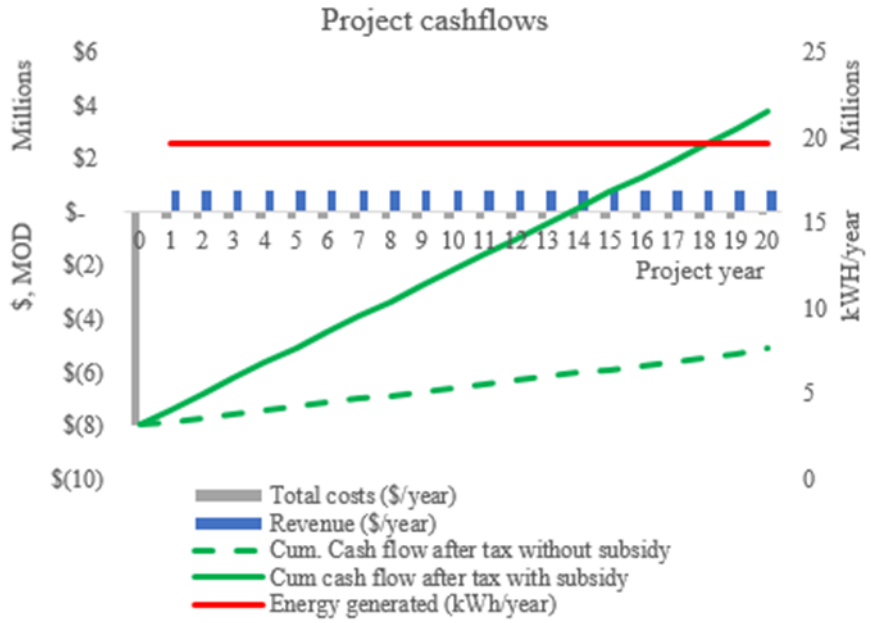

Table A.3
**Resource Classification**

| | |
|---|---|
| Socio-Economic Viability (E): | The project is defined, access to source and market secured via contracts. The project entitlement is 100% with royalties accounted for in the project economics. The project economics show that cumulative positive cashflow will be obtained but only through the application of price subsidies. The project will be developed in less than 5 years and thus meets the reasonable timeframe criteria. |
| Sub-class definition: | "Extraction and sale is not economic on the basis of current market conditions and realistic assumptions of future market condition, but is made viable through government subsidies and/or other consideration." |
| Sub-class: | E1.2 |
| Project Status and Feasibility (F): | The project is feasible, about to commence construction and the developer has committed the necessary equity funding and secured the bank loan. |
| Sub-class definition: | "Capital funds have been committed, and implementation of the development Project or mining operation is underway." |
| Sub-class: | F1.2 |
| Project uncertainty (G): | The wind energy source and associated uncertainty has been measured at the location of the project and the results for the estimates corresponding to the high (G1), moderate (G2) and low (G3) confidence for the cumulative energy produced over the project lifetime are provided in Table A. |
| Categories: | G1, G2 and G3 |
| Effective Date of estimate: | 1 January 20XX |
| Evaluator: | UNFC Wind Sub-group, independent professional and licensed consultant to the wind farm developer |

## B. Case 2: Single onshore wind farm (phase II, refurbished after end of phase I)

Table A.4
**Details of Single onshore wind farm (phase I)**

| | |
|---|---|
| Project type: | The same onshore wind farm from phase I, with known wind energy source, located in country ABC, for commercial generation of electricity, which is expected to be sold to the same local electricity utility company as specified in Case 1 (Phase I of the project). |
| Project scope: | 10 wind turbines with 800 kW rating per turbine (higher capacity than in phase I due to assumed technology improvements) |
| Capital cost (incl. installation): | $562,500/turbine (turbine refurbishment cost, > 30% of a new turbine, thus making this new phase a re-investment project) |
| Operating costs per year: | $18,750/year (assumed to increase from phase I) |
| Technical lifespan of turbines: | additional 20 years |
| Total area leased: | 20 hectares (ha) (unchanged from phase I) |
| Royalties: | $3000/ha (assumed to increase from phase I) |
| Electricity price: | $0.04/kWh (excl. government subsidy) |
| Full load factor: | 25% (low estimate, high confidence) |
| | 30% (best estimate, moderate confidence) |
| | 40% (high estimate, low confidence) |

| | |
|---|---|
| Financing cost of capital: | 25% of capital to be borrowed at 5% interest rate over a 20-year loan period<br>Asset depreciation is linear of the project lifetime |
| Corporate tax rate: | 25% |
| Wind energy source: | The wind speeds at a given height have been measured over a period of two years for phase I. The wind class, as well as daily and seasonal variance in wind speed is known. The wind speeds and wind class is unchanged from the assessment for phase I. |
| Wind energy product: | Electricity (measured in TJ), sold at the reference point (see below) |
| Wind energy resource: | The total amount of electricity sold over the lifetime of the project, which is an additional 20 years determined by the technical lifespan of the refurbished wind turbines. |
| Reference point: | The reference point is the electricity sales meter, connecting the wind farm with the electric grid, which is operated by the electric utility company and buyer of the electricity. It is assumed that the utility company and buyer from phase I remains in place. |
| Project entitlement: | The wind farm developer operator is a single commercial company with 100% entitlement to the project, its revenues and obligations. The company finances the costs partly through equity and partly through bank loans. |
| Project timeline: | The refurbishment of the wind farm and any required repair or upgrading of infrastructure will begin in the first year of phase II. The refurbishment is expected to take less than one year. |
| Access to Source: | The lease for the land has not been secured but the lease from phase I includes the option to extend for an additional 20 years. The associated royalties need to be negotiated as part of the lease extension and royalty costs are assumed to increase relative to phase I.<br>The wind farm developer has not secured the permits from the local government to refurbish and operate the wind farm for the additional 20 years of phase II. The necessary permits will be sought before the refurbishment will commence.<br>Based on the experience with phase I, it is assumed that the local community will continue to support the project and will not oppose the refurbishment and phase II. If a new environmental assessment is required, then such a study will commence about 1-2 years before the start of phase II. |
| Access to Market: | The power purchase agreement has not been signed for an additional 20 years but the agreement for phase I provides the option to extend and negotiate new electricity prices. |
| Economic assessment: | The cashflow chart below (expressed in MOD, Money of Day) shows that the project will reach positive cumulative cashflow over the project lifetime at an assumed sales price without any application of government subsidy. The cashflow shown below is undiscounted in nominal terms with phase I from year 0 to 20 and phase II from year 21 to 41. |

Figure A.II
**Cashflow assessment**

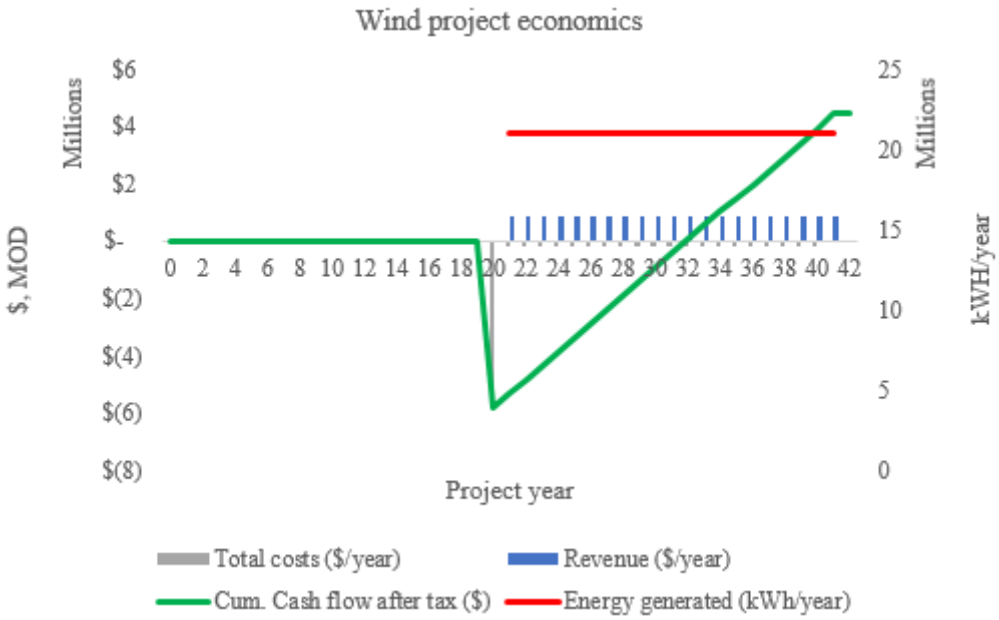

Table A.5
**Resource Classification**

| | |
|---|---|
| Socio-Economic Viability (E): | The project (i.e. the turbine refurbishment) is defined but access to source and market have not been secured via contracts. The project entitlement is assumed to remain as 100% with royalties accounted for in the project economics. The project economics show that cumulative positive cashflow will be obtained without the application of price subsidies. As the project will not be developed in a reasonable time frame or the foreseeable future (i.e. within the next 5 years), the applicable category is E3. Additionally, many project assumptions (e.g. capital cost, electricity price) are not sufficiently known at this early stage of phase II. |
| Sub-class definition: | "Economic viability of extraction cannot yet be determined due to insufficient information (e.g., during the exploration phase)." |
| Sub-class: | E3.2 |
| Project Status and Feasibility (F): | Based on the evaluation of phase I, the project is feasible and the developer has plans to extend phase I by 20 years. While an early assessment of phase II is complete, the project is not ongoing in terms of securing permits, contracts or funding. |
| Sub-class definition: | "Project activities are on hold and/or where justification as a commercial development may be subject to significant delay." |
| Sub-class: | F2.2 |
| Project uncertainty (G): | The wind energy source and associated uncertainty has been measured at the location of the project and the results for the estimates corresponding to the high (G1), moderate (G2) and low (G3) confidence for the cumulative energy produced over the project lifetime are provided in Table A. The wind measurements taken for phase I are used for the estimation of the wind energy resource of phase II. |
| Categories: | G1, G2 and G3 |
| Effective Date of estimate: | 1 January 20XX |
| Evaluator: | UNFC Wind Sub-group, independent professional and licensed consultant to the wind farm developer |

## C. Case 3: Multiple, notional, phased offshore wind farm development for national resource assessment

Table A.6
**Details of Multiple, notional, phased offshore wind farm development for national resource assessment**

| | |
|---|---|
| Project type: | Four phases of notional (generic or standard) offshore wind farms located within 50 km of the shorelines of country ABC. |
| Project scope: | |
| Phases 1/2/3/4: | 500/700/1000/1500 wind turbines (per phase) |
| Capital cost (incl. installation): | ~$3.0-.3.5 million/turbine |
| Operating costs per year: | 10-15% of capital investment |
| Technical lifespan of turbines: | 35 years for each phase |
| Total area considered: | ~11,000 ha, within 50km, 100m water depth |
| Royalties: | $3000/ha |
| Electricity price: | $0.06/kWh (excl. government subsidy) |

| | |
|---|---|
| Full load factor: | 40% (low estimate, high confidence)<br>50% (best estimate, moderate confidence)<br>70% (high estimate, low confidence) |
| Financing cost of capital: | excluded from evaluation<br>Asset depreciation is linear for the project lifetime |
| Corporate tax rate: | 25% |
| Wind energy source: | The wind speeds at a given height (100m) have been measured in some locations in the area considered for potential development. The wind class, as well as the daily and seasonal variance in wind speed, are not fully known in all areas. |
| Wind energy product: | Electricity (measured in TJ), sold at the reference point (see below) |
| Wind energy resource: | The total amount of electricity sold over 50 years. It is assumed that the turbines will be refurbished at the end of the initial technical lifetime (35 years). |
| Reference point: | The reference point is the electricity sales meter, connecting the wind farm with the onshore electric grid, which is assumed to be in place and operated by a yet to be defined electric utility company and buyer of the electricity. |
| Project entitlement: | To be determined by the project owners, operating company or JV |
| Project timeline: | 35 years per phase, extended for an additional 35 years after refurbishment. The assessment of the energy produced is a notional 50 years. |
| Access to Source: | It is assumed that the national regulatory body will issue the relevant permits to build and operate the offshore wind farms. |
| Access to Market: | There are no power purchase agreements in place. It is assumed that they will be in place once individual projects for each or all phases mature technically and commercially. |
| Economic assessment: | The cumulative cash flow chart below (expressed in MOD, Money of Day) shows the estimated economic outlook for the next 50 years for all four phases of potential development, given the current notional assumptions for the generic projects. |

Figure A.III
**Cashflow assessment**

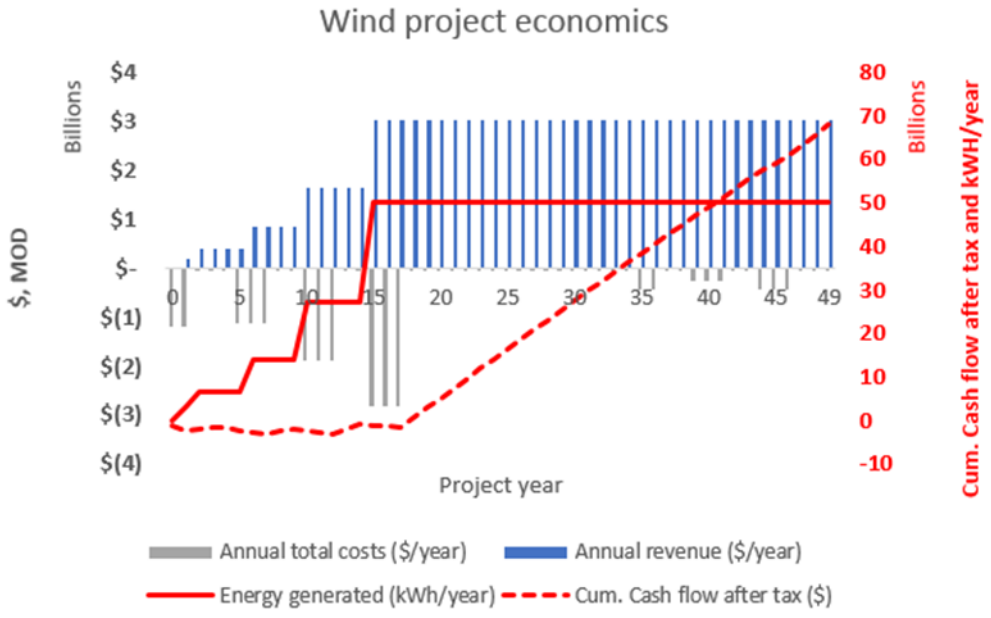

Table A.7
**Resource Classification**

| | |
|---|---|
| Socio-Economic Viability (E): | The project(s) are not defined, do not have access to the source and market access has not been secured via contracts. The project entitlement is not known but it is assumed that for the assumed areas of development that the relevant permits and contracts can be obtained in the future when projects are defined. Some phases can be developed in a reasonable time frame or the foreseeable future (i.e. within the next 5 years) but some could be developed later. |
| Sub-class definition: | "Economic viability of extraction cannot yet be determined due to insufficient information (e.g., during the exploration phase)." |
| Sub-class: | E3.2 |
| Project Status and Feasibility (F): | The generic projects are deemed technically feasible but there are no defined development plans. The wind source assessment requires further measurements over larger areas, but currently locally available measurements of wind speeds indicate that a generic project development is technically and economically viable. |
| Sub-class definition: | "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. |
| Sub-class: | F3.2 |
| Project uncertainty (G): | The wind energy source and associated uncertainty has been measured at the location of the project and the results for the estimates corresponding to the high (G1), moderate (G2) and low (G3) confidence for the cumulative energy produced over the project lifetime are provided in Table A. The wind measurements taken for phase I are used for the estimation of the wind energy resource for later phases. |
| Categories: | G1, G2 and G3 |
| Effective Date of estimate: | 1 January 20XX |
| Evaluator: | UNFC Wind Sub-group, independent professional and licensed consultant to the national energy advisory body of country ABC |

# Annex II

## Glossary of Terms

A comprehensive glossary of terms is provided in the UNFC Renewable Energy Specifications.

| *Term* | *Definition* |
|---|---|
| *Category* | *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.* |
| *Competent Person* | *Competent Person is one who has the ability to put skills, knowledge and experience into practice in order to perform activities or a job in an effective and efficient manner for resource classification, management and reporting.* |
| *Class(es)* | *Primary level of resource classification resulting from the combination of a Category from each of the three Criteria (axes).* |
| *Criteria* | *UNFC 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.* |
| *Economic Limit* | *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.* |
| *Entitlement* | *The quantity of Renewable Energy Resource that accrues to a Project's participant.* |
| *Evaluator* | *Person, or persons, performing resource estimation and/or Classification; see also Competent Person definition.* |
| *Exploration Project* | *A Project that is associated with one or more Potential Deposits (as defined below).* |
| *Generic Specifications* | *Specifications (as documented in this Specifications Document) that apply to the classification of quantities of any commodity using UNFC.* |
| *Numerical Code* | *Numerical designation of each Class or Sub-class of resource quantity as defined by UNFC. Numerical Codes are always quoted in the same sequence (i.e. E;F;G).* |
| *Potential Deposit* | *A wind source that has not yet been demonstrated to exist or cannot be recovered with known technologies.* |
| *Project* | *A Project is a defined development 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.* |

| *Term* | *Definition* |
|---|---|
| *Renewable Energy Product* | *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* |
| *Renewable Energy Resources* | *The cumulative quantities of extractable Renewable Energy Products from the Renewable Energy Source, measured at the Reference Point.* |
| *Renewable Energy Source* | *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.* |
| *Specifications* | *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 UNFC 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.* |
| *Specifications Document* | *Specifications for the application of the United Nations Framework Classification for Resources (UNFC).* |
| *Sub-categories* | *Optional subdivision of Categories for each of the fundamental Criteria of economic and social viability, project status and feasibility, and knowledge regarding the source and resource. Definitions of Sub-categories are provided in Annex II to UNFC.* |
| *Sub-classes* | *Optional subdivision of resource classification based on Project maturity principles resulting from the combination of Sub-categories.* |
| *Système International d'Unités* | *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.* |
| *UNFC* | *United Nations Framework Classification for Resources (formerly known as United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources (ECE Energy Series No. 42)).* |