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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Gird integration of renewable energy generation – Terms and definitions

Intégration de la production d'énergie renouvelable aux réseaux électriques – Termes et définitions

IEC 62934:2021-04(en-fr)

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Grid integration of renewable energy generation – Terms and definitions

Intégration de la production d'énergie renouvelable aux réseaux électriques – Termes et définitions

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

GRID INTEGRATION OF RENEWABLE ENERGY GENERATION – TERMS AND DEFINITIONS

FOREWORD

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The text of this International Standard is based on the following documents:

Draft	Report on voting
8A/75/FDIS	8A/79/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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- amended.

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INTRODUCTION

The purpose of this terminology document is to provide terms and definitions for all publications under the responsibility of SC 8A. In this document, renewable energy generation is the electric power generation which uses renewable energy as its primary source for the conversion into electricity.

All SC 8A normative documents to be published should keep consistency with this International Standard (IS). This IS will be revised together with other SC 8A publications in order to avoid mismatches when necessary.

From the technical point of view, grid integration of renewable energy generation is a interdisciplinary complex technical field which is concerned with basic equipment, system integration, control and protection, operation and dispatch, market and trade and so on. Without a strong standardization of terminology, focal terms can have a different understanding by different countries, parties, and technical areas. Harmonised vocabulary is critical also from the market point of view. It impacts economics and this can become a barrier to commerce. The correct comparison among different options is fundamental, therefore basic terms and definitions impact economic decisions.

Several IEC product standards give definitions of certain terms which are necessary for the understanding of how to design, manufacture and use of those products. The International Electrotechnical Vocabulary (IEV, IEC 60050, http://www.electropedia.org) and the IEC Glossary (http://std.iec.ch/glossary) allow on-line access to this information.

Terms and definitions of this document have been harmonized with the IEV, the IEC Glossary and other IEC documents as far as possible. Definitions not included in this terminology standard may be found elsewhere in other IEC documents.

The use of abbreviations has been optimized, on the one hand to avoid tedious repetition and, on the other hand, to avoid confusion. A minimum set of abbreviations is identified in Clause 4 of this document; the other terms are written out in full spelling when needed.

GRID INTEGRATION OF RENEWABLE ENERGY GENERATION – TERMS AND DEFINITIONS

1 Scope

This terminology document provides terms and definitions in the subject area of grid integration of renewable energy generation. The technical issues of grid integration mainly focus on the issues caused by renewable energy generation with variable sources and/or converter based technology, such as wind power and photovoltaic power generation. Some renewable energy generations such as hydro power and biomass power with a relatively continuously available primary energy source and a rotating generator are conventional sources of generation, and are therefore not covered in this document.

The intention of this document is to answer the question "what do the words mean" and not "under what conditions do the terms apply".

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions for renewable energy generation

3.1.1
renewable energy
RE
primary energy, the source of which is constantly replenished and will not become depleted

Note 1 to entry: Examples of renewable energy are: wind, solar, geothermal, hydropower, etc.

Note 2 to entry: Fossil fuels are non renewable.

[SOURCE: IEC 60050-617:2009, 617-04-11 modified, examples of renewable energy are added in Note 1 to entry."]

3.1.2
variable renewable energy
VRE
subset of renewable energy, the source of which is not continuously available and cannot be stored or controlled

EXAMPLE Wind energy, solar energy, wave energy.

3.1.3
renewable energy generation
generation of electrical energy, which uses renewable energy as the primary energy source for the conversion into electricity

3.1.4
variable renewable energy generation
subset of renewable energy generation, which uses variable renewable energy as the primary energy source for the conversion into electricity

EXAMPLE Wind power generation, photovoltaic power generation, concentrated solar power generation, wave power generation.

Note 1 to entry: The primary energy from variable renewable energy sources is in most cases not able to be stored and therefore the electricity generated is constrained by the availability of the energy source.

3.1.5
renewable energy generating unit
REGU
smallest set of equipment which can generate electricity from renewable energy and can feed the electricity into an electric power network

Note 1 to entry: Several typical forms of renewable energy generating unit are shown in Annex A.

3.1.6
renewable energy power plant
collection of renewable energy generating units connected to an electric power network through one or more points of connection, including auxiliaries and connection equipment

Note 1 to entry: Two typical forms of renewable energy power plant are shown in Annex A.

3.1.7
power collection system
<renewable energy power plant> electrical system that collects the electricity from at least one renewable energy generating unit and feeds this electricity into an electric power network, usually comprising transformers and overhead lines or cables

3.1.8
substation
plant substation
<renewable energy power plant> transformer substation or switching substation of a renewable energy power plant through which the output power of all generating units is transmitted to the electric power network

3.1.9
point of generating unit connection
PGUC
point that is part of the generating unit and identified by the manufacturer as a reference point at which the generating unit is connected to the power collection system

3.1.10
point of connection
POC
reference point on the electric power network where the user's electrical facility is connected

[SOURCE: IEC 60050-617:2009, 617-04-01]

3.1.11
point of common coupling
PCC
point in an electric power system, electrically nearest to a particular load or the POC of a power plant, at which other loads/power plants are, or may be, connected

Note 1 to entry: These loads can be either devices, equipment or systems, or distinct customer's installations.

[SOURCE: IEC 60050-614:2016, 614-01-12, modified – "or the POC of a power plant" is added and "network users' installations" is changed to "customer's installations"]

3.1.12
cluster
<renewable energy power plant> two or more neighboring renewable energy power plants which are connected to the electric power network via a common substation

Note 1 to entry: Typical form of cluster is shown in Annex A.

3.1.13
distributed energy resources
DER
generators (with their auxiliaries, protection and connection equipment), including loads having a generating mode (such as electrical energy storage systems), connected to a low-voltage or a medium-voltage network

[SOURCE: IEC 60050-617:2017,617-04-20]

3.1.14
distributed generation
DG
generation of electric energy by multiple sources which are connected to the power distribution system

[SOURCE: IEC-60050-617:2009, 617-04-09]

3.1.15
virtual power plant
VPP
group of distributed energy resources and controllable loads which combine to function as a dispatchable unit

Note 1 to entry: A virtual power plant can be used for the purpose of participating in the electricity market or aggregating ancillary services.

[SOURCE: IEC 60050-617:2017, 617-04-27, modified − controllable loads are included in the definition since they form an essential part of virtual power plant]

3.2 Terms and definitions for grid aspects and requirements

3.2.1
power system

3.2.1.1
electric power system
electricity supply system
< broad sense> all installations and plant provided for the purpose of generating, transmitting and distributing electricity

[SOURCE: IEC 60050-601:1985, 601-01-01]

3.2.1.2
electric power network
particular installations, substations, lines or cables for the transmission and distribution of electricity

Note 1 to entry: The boundaries of the different parts of this network are defined by appropriate criteria, such as geographical situation, ownership, voltage, etc.

[SOURCE: IEC 60050-601:1985, 601-01-02]

3.2.1.3
bulk power system
BPS
bulk electricity system
portion of the electric power system comprising the facilities used for the generation and transmission of electric energy

Note 1 to entry: The extent of the bulk power system is usually limited to the means for production and transmission of electric energy to major industrial and distribution centers.

Note 2 to entry: In English, the term "composite system" is also used for this concept.

[SOURCE: IEC 60050-601:1985, 601-01-33]

3.2.2
electrical quantities

3.2.2.1
nominal voltage
U_n
<power plant> value of the voltage (line to line) by which a power plant is designated and identified, usually defined at the POC

[SOURCE: IEC 60050-826:2004, 826-11-01, modified − supplementary information is added to indicate that the nominal voltage of a power plant is usually defined at the point of connection]

3.2.2.2
rated power
rated active power
maximum continuous power output which a renewable energy generating unit or plant is designed to achieve under normal operating conditions

Note 1 to entry: In some standards and grid codes this term is referred as "rated capacity".

[SOURCE: IEC 60050-415:1999, 415-04-03, modified – "wind turbine" is changed to "renewable energy generating unit or plant" to adapt the scope of this standard]

3.2.2.3
nominal active power
P_n
nominal value of the active power generation of a renewable energy generating unit or power plant, which must be stated by the manufacturer or the designer

Note 1 to entry: It is used as a base for calculating quantities in relation to that generating unit or power plant.

3.2.2.4
nominal apparent power
S_n
apparent power from a renewable energy generating unit or power plant while operating at nominal current and nominal voltage and frequency within the maximum permissible reactive power

Note 1 to entry:

$$S_n = \sqrt{3} U_n I_n \quad (1)$$

3.2.2.5
nominal current
I_n
nominal value of the current from a renewable energy generating unit or power plant, which must be calculated from nominal active power and nominal voltage at specified or designed power factor

Note 1 to entry:

$$I_n = \frac{P_n}{\sqrt{3} U_n \cdot |PF|} \quad (2)$$

3.2.2.6
registered power
active/apparent power of a power plant registered by the plant owner at the network operator's or regulator's registry

3.2.2.7
active power ramp rate
rate of change of active power during a specified period

3.2.3
type of generator

3.2.3.1
synchronous machine type of generator
generating unit connected to an electric power network via a synchronous generator

3.2.3.2
asynchronous machine type of generator
generating unit connected to an electric power network via an asynchronous generator

3.2.3.3
converter type of generator
generating unit connected to an electric power network via a power electronic converter

3.2.4
short-circuit
accidental or intentional conductive path between two or more conductive parts forcing the electric potential differences between these conductive parts to be equal or close to zero

[SOURCE: IEC 60050-614:2016, 614-02-02]

3.2.5
short-circuit current
I_k
<renewable energy power plant> current that a renewable energy power plant delivers to the point of connection resulting from a short-circuit in the external electric power system

3.2.6
short-circuit power
S_k
the product of the current in the short-circuit at a point of a system and a conventional voltage, generally the operating voltage

Note 1 to entry: Using physical units for line current (A) and nominal voltage (V), the product should also include the factor $\sqrt{3}$.

[SOURCE: IEC 60050-601:1985, 601-01-14, modified – Note 1 to entry is added]

3.2.7
short-circuit ratio
SCR
ratio of the three-phase short-circuit power at POC/PGUC to the nominal active power of a renewable energy power plant or generating unit

Note 1 to entry: SCR is a common analytical indicator used in the industry to quantify system strength.

Note 2 to entry: There is no industry consensus on the exact definition and methodology for calculating the SCR, particularly for applications with several adjacent renewable energy power plants, or for a renewable energy power plant adjacent to HVDC terminals, see CIGRE TB 671.

3.2.8
weighted short-circuit ratio
WSCR
index based on short-circuit ratio to assist in defining operational limits for total transmission of active power from inverter-based generators across key power system interfaces

Note 1 to entry:

$$WSCR = \frac{\sum_{i=1}^{N} S_{ki} \cdot P_{ni}}{\left(\sum_{i=1}^{N} P_{ni}\right)^2} \quad (3)$$

Note 2 to entry: S_{ki} is the short-circuit power at bus i without current contribution from renewable energy power plants, P_{ni} is the nominal power of renewable energy power plant to be connected at bus i, N is the number of power plants fully interacting with each other, i is the summation index of the renewable energy power plants.

3.2.9
composite short-circuit ratio
CSCR
index based on short-circuit ratio, which calculates an aggregate SCR for multiple renewable energy power plants by creating a common bus and tying all renewable energy power plants of interest together at that common bus

Note 1 to entry:

$$CSCR = \frac{S_{kv}}{\sum_{i=1}^{N} P_{ni}} \quad (4)$$

Note 2 to entry: S_{kv} is the short-circuit power at the virtual common bus without current contribution from the renewable energy power plants. P_{ni} is the nominal power of renewable energy power plant i, N is the number of renewable energy power plants to be considered.

Note 3 to entry: Composite short-circuit ratio is used to estimate the equivalent system impedance seen by multiple renewable energy power plants.

3.2.10
short-circuit ratio with interaction factors
SCRIF
index based on short circuit ratio, which considers interaction voltage sensitivity between electrically close renewable energy power plants

Note 1 to entry:

$$SCRIF_i = \frac{S_{ki}}{P_{ni} + \sum_{j(j \neq i)} \left(IF_{ji} \cdot P_{nj} \right)} \quad (5)$$

Note 2 to entry: S_{ki} is the short-circuit power at the POC of renewable energy power plant i without current contribution from the other renewable energy power plants, P_{ni} is the nominal power of renewable energy power plant i, IF_{ji} is the voltage change at bus j (ΔU_j) for a voltage change at bus i (ΔU_i), as follows:

$$IF_{ji} = \frac{\Delta U_j}{\Delta U_i} \quad (6)$$

Note 3 to entry: SCRIF is proposed to capture the voltage change at one bus resulting from a voltage change at another bus. When multiple renewable energy power plants are located very close to each other, they share the grid strength and short circuit level; hence, the grid strength is actually much lower than the overall short-circuit level calculated at that bus or buses.

3.2.11
power quality
characteristics of the electric current, voltage and frequencies at a given point in an electric power system, evaluated against a set of reference technical parameters

Note 1 to entry: These parameters might, in some cases, relate to the compatibility between electricity supplied in an electric power system and the loads connected to that electric power system.

[SOURCE: IEC 60050-617:2009, 617-01-05]

3.2.12
harmonic
harmonic component
sinusoidal component of the Fourier series of a periodic quantity, the harmonic order of which is an integer number greater than one

Note 1 to entry: A component of harmonic order n (with $n > 1$) is generally designated "n^{th} harmonic". The designation of the fundamental component as the "1st harmonic" is not recommended.

[SOURCE: IEC 60050-103:2009, 103-07-25]

3.2.13
interharmonic component
sinusoidal component of the Fourier series of a periodic quantity the harmonic order of which is a non-integer rational number

Note 1 to entry: Interharmonic components occur only when a harmonic order is defined in relation to a reference fundamental frequency not identical to the fundamental frequency.

[SOURCE: IEC 60050-103:2009, 103-07-27]

3.2.14
voltage deviation
difference between the supply voltage at a given instant and the declared supply voltage

[SOURCE: IEC 60050-614:2016, 614-01-04]

3.2.15
voltage fluctuation
series of voltage changes or continuous variation of the RMS or peak value of the voltage

[SOURCE: IEC 60050-614:2016, 614-01-06]

3.2.16
voltage dip
sudden voltage reduction at a point in an electric power system, followed by voltage recovery after a short time interval, from a few periods of the sinusoidal wave of the voltage to a few seconds

[SOURCE: IEC 60050-614:2016, 614-01-08]

3.2.17
flicker
impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

[SOURCE: IEC 60050-614:2016, 614-01-28]

3.2.18
unbalance factor
in a three-phase system, degree of unbalance expressed by the ratio (in per cent) of the RMS values of the negative sequence component (or the zero sequence component) to the positive sequence component of the fundamental component of the voltage or the electric current

[SOURCE: IEC 60050-614:2016, 614-01-33]

3.2.19
rate of change of frequency
ROCOF
rate at which the system frequency changes

3.2.20
island
<electric power system> part of an electric power system that is electrically disconnected from the remainder of the interconnected electric power system but remains energized from the local electric power sources

Note 1 to entry: An island can be either the result of the action of automatic protections or the result of a deliberate action.

Note 2 to entry: An electric island can be stable or unstable.

[SOURCE: IEC 60050-692:2017, 692-02-11 modified – the original term "electric island" is changed to "island"]

3.2.21
unintentional island
island that is not anticipated by the relevant network operator

[SOURCE: IEC 60050-617:2017, 617-04-18]

3.2.22
intentional island
island resulting from planned action(s) of automatic protections, or from deliberate action by the responsible network operator, or both, in order to keep supplying electrical energy to a section of an electric power system

[SOURCE: IEC 60050-617:2017, 617-04-17]

3.2.23
islanding
the process whereby a power system is split into two or more islands

Note 1 to entry: Islanding is either a deliberate emergency measure, or the result of automatic protection or control action, or the result of human error.

[SOURCE: IEC 60050-603:1986, 603-04-31]

3.2.24
island operation
independent operation of part of a network, that is isolated after being disconnected from the interconnected system, having at least one generator supplying power to this network and controlling frequency and voltage

3.2.25
ride-through

3.2.25.1
fault ride-through
FRT
ability of a generating unit or power plant to stay connected during specified faults in the electric power system

3.2.25.2
under-voltage ride-through
UVRT
ability of a generating unit or power plant to stay connected during a voltage dip

Note 1 to entry: In some documents, the expression "low-voltage ride-through (LVRT)" is used with a similar meaning.

3.2.25.3
over-voltage ride-through
OVRT
ability of a generating unit or power plant to stay connected during a limited duration rise of grid voltage

Note 1 to entry: In some documents, the expression "high-voltage ride-through (HVRT)", is used with a similar meaning.

3.2.25.4
under-frequency ride-through
UFRT
ability of a generating unit or power plant to stay connected during a limited duration drop of system frequency

3.2.25.5
over-frequency ride-through
OFRT
ability of a generating unit or power plant to stay connected during a limited duration rise of system frequency

3.2.26
system oscillation

3.2.26.1
low-frequency oscillation
LFO
electrical oscillation occurring in an electric power system at a frequency usually between 0,1 Hz to 3 Hz

Note 1 to entry: According to an extensive survey of IEEE technical literatures, the range 0,1 Hz to 3 Hz covers the majority of low-frequency oscillation events.

3.2.26.2
sub-synchronous oscillation
SSO
electrical oscillation occurring in an electric power system at a frequency smaller than the nominal system frequency and generally sustained for a minute or more

3.2.26.3
sub-synchronous resonance
SSR
resonance between adjacent equipment in an electric power system, generating oscillations at a frequency smaller than the nominal system frequency and generally sustained for a minute or more

[SOURCE: IEC 60050-614:2016, 614-01-18]

3.2.26.4
harmonic resonance
phenomenon producing amplification of harmonic components of the voltage or current resulting from sustained oscillation between the inductance and capacitance of adjacent items of equipment or subsystems

[SOURCE: IEC 60050-614:2016, 614-01-17]

3.3 Terms and definitions for modelling, analysis and planning

3.3.1
electrical simulation model
set of mathematical equations or logical functions used in time or frequency domain digital simulations which describe the dynamic characteristics of a facility or certain equipment

3.3.2
unit model
model for an individual renewable energy generating unit

3.3.3
lumped model
<renewable energy power plant> model for renewable energy power plant using simple scaling method

3.3.4
aggregated model
<renewable energy power plant> model for renewable energy power plant using specified aggregation algorithm

3.3.5
generic model
model that can be adapted to simulate different types of renewable energy generating units or power plants by changing the model parameters

3.3.6
dynamic simulation
<electrical power system> use of a computer program to model and retrieve the time varying behaviour of power system or parts of the system, which are typically described by differential-difference-algebraic equations

3.3.7
electromechanical simulation
root mean square simulation
RMS simulation
dynamic simulation method based on root mean square model, which usually focuses on the electromechanical processes of an electric power system under disturbance, and the typical observation time interval is from several seconds to tens of seconds after disturbance

3.3.8
electromagnetic transient simulation
EMT simulation
dynamic simulation method to model the electro-magnetic transient behaviour of an electric power system, where instantaneous values are used in the process, and the typical observation time interval is from several microseconds to several seconds after a disturbance

3.3.9
production simulation
simulation of the dispatching process in electric power systems to determine the generation schedule of every electricity generating plant including a cost analysis

3.3.10
expected energy not supplied
EENS
<electric power system> expected value of the energy not supplied, in a given time interval, resulting from electric power system deficiencies

[SOURCE: IEC 60050-692:2017, 692-11-01]

3.3.11
penetration
<renewable energy generation> ratio of renewable energy generation quantity to a certain system quantity, used to evaluate the utilization level of renewable energy generation in a certain area of an electric power system

Note 1 to entry: Relevant quantities are those defined in 3.3.12, 3.3.13, 3.3.14 and 3.3.15.

3.3.12
installation penetration
ratio of nominal power of all renewable energy power plants to nominal power of all sources in a certain area of an electric power system

3.3.13
demand penetration
ratio of nominal power of all renewable energy power plants to the maximum demand in a certain area of an electric power system

3.3.14
power penetration
ratio of the sum of the active power output of renewable energy power plants to the cumulative load at a certain moment in a certain area of an electric power system

3.3.15
energy penetration
electricity penetration
ratio of the electricity generated by renewable energy power plants to the total load consumption during a certain defined period in a certain area of an electric power system

Note 1 to entry: Defined period could be one day, one month, one year or other.

3.3.16
credit of renewable energy generation

3.3.16.1
capacity credit
<renewable energy> under the premise of equal reliability, capacity of a conventional and dispatchable power plant which can be replaced by a renewable energy power plant

3.3.16.2
confidence coefficient
ratio of the credible capacity in the installed capacity of renewable energy generation

3.4 Terms and definitions for control and protection

3.4.1
unit control
control determined and executed on individual generating units

3.4.2
plant control
control determined by a plant controller and executed by generating units and other controllable equipment in the plant through communication

3.4.3
plant controller
set of control functions and software libraries integrated in a single automation system that make it possible to control the overall performance and functionality of a renewable energy power plant as a single generating plant in the point of connection

Note 1 to entry: The plant controller coordinates the P-f and the Q-V control at the plant level, adjusting the active and reactive power output in response to the settings received from TSO or DSO and ensuring compliance with the grid code requirements.

Note 2 to entry: The plant controller dispatches the settings of individual generating units and of all other devices involved in the performance at the POC, as transformers tap changers, energy storage, capacitor banks or FACTS

3.4.4
active power control of renewable energy power plant

3.4.4.1
constant active power control
control to maintain the active power of a renewable energy power plant within a given tolerance around a target value which is lower than the available power

3.4.4.2
delta active power control
control to maintain the active power of a renewable energy power plant at a value which is less than the available power by a configured value

3.4.4.3
frequency control
automatic active power regulation in response to a measured deviation of system frequency beyond pre-set thresholds, in order to maintain stable system frequency

Note 1 to entry: Frequency control comprises several mechanisms, including frequency response (P(f) droop = proportional controller, primary control) and secondary control (integrative controller).

3.4.5
reactive power control of renewable energy power plant

3.4.5.1
Q control
control of reactive power delivered (usually at the POC) independently of the active power generated

Note 1 to entry: The plant controller coordinates the Q control at the plant level, adjusting the reactive power generated in response to the settings received from TSO or DSO and ensuring compliance with the grid code requirements.

3.4.5.2
power factor control
control of reactive power delivered (usually at the POC) proportional to the active power generated

Note 1 to entry: The plant controller coordinates the Q control at the plant level, adjusting the reactive power generated in response to the settings received from TSO or DSO and ensuring compliance with the grid code requirements.

3.4.5.3
reactive power voltage droop control
Q-by-U control
control of reactive power delivered proportional to the deviation of the grid voltage measured at the POC from a set value

Note 1 to entry: The plant controller coordinates the Q-by-U control at the plant level (usually at the POC), adjusting the reactive power generated in response to the settings received from TSO or DSO and ensuring compliance with the grid code requirements.

3.4.6
enhanced control

3.4.6.1
inertia control
synthetic inertia control
behaviour of a renewable energy generating unit or plant with a converter type interface to emulate the effect of a rotating mass on the active power feed-in as synchronous generators would do responding to a rapid frequency change

Note 1 to entry: Inertial control is also designed as "synthetic inertia" or "virtual inertia control".

Note 2 to entry: Inertial control can be performed by the generating unit control, at plant level through plant controller, or both.

Note 3 to entry: The effect of a synchronous generating unit such as the rotor maintains its state of uniform rotational motion and angular momentum unless an external torque is applied.

3.4.6.2
damping control
active and reactive power control performance of a renewable energy generating unit or plant with converter type interface intended to dampen system oscillations within a specified frequency range

Note 1 to entry: Damping control is also designed as Power System Stabilizer (PSS).

Note 2 to entry: Damping control can be performed by the generating unit control, at plant level through plant controller, or both.

3.4.7
virtual synchronous generator
VSG
virtual synchronous machine
VSM
convertor equipped with a controller whose algorithm simulates the dynamic behaviour of a synchronous machine

Note 1 to entry: The VSM is intended to achieve improved performance over the DQCI/PLL convertors (dq-axis current-injection/Phase Lock Loop) concerning ROCOF, loss of synchronising torque and reference voltage, frequency stability, voltage stability, sub-synchronous oscillations and fault current in-feed.

Note 2 to entry: The new converter control algorithms aimed to provide "synchronous-like" performance, including inertia support, short-circuit power, voltage and frequency control and black-start capabilities, are designed as "grid-forming converters" too. There is no consensus over the exact meaning of these terms and the electrical capabilities assigned to them, except that the converter should provide a voltage behind a reactance, like a SM. In opposition, the "state-of-the-art" DQCI/PLL converters are sometimes designed as "grid-feeding" or "grid-following" converters.

3.4.8
interface protection
electrical protection required to ensure that a generator is disconnected for any event that could impair the integrity or degrade the safety of the network it is connected to

Note 1 to entry: The interface protection shall be insensitive to voltage and frequency variations in the network within the voltage and frequency settings.

Note 2 to entry: The interface protection can also be realised in a power control device.

3.4.9
anti-islanding protection
protection function or combination of protection functions preventing an unintentional island to be supplied with electrical energy by distributed energy resources

Note 1 to entry: An anti-islanding protection usually includes the detection of system conditions which could lead to an unintentional island.

[SOURCE: IEC 60050-617: 2017, 617-04-19]

3.4.10
dynamic reactive power support
ability of a renewable energy generating unit to deliver quickly additional reactive power during and after an abnormal voltage change, supporting system voltage retention

Note 1 to entry: This performance is referred to as "fast fault current injection".

Note 2 to entry: Timing and accuracy of dynamic support by fast fault current injection may include several stages during a fault and after its clearance.

Note 3 to entry: Grid codes could define requirements for symmetrical injections (3-phase faults) and unsymmetrical ones (1-phase or 2-phase faults).

3.4.11
post fault active power recovery
process of renewable energy generating unit or power plant to restore its active power from a temporary value during system fault to a stable value after the fault is cleared

3.4.12
black-start capability
recovery capability of a generating unit or power plant from a shutdown without any electrical energy supply external to the power-generating facility

3.5 Terms and definitions for forecasting

3.5.1
power forecasting
active power or electricity output estimate of one or more renewable energy power plants in a specified future time scale

3.5.2
hour-ahead power forecasting
active power or electricity output estimate of one or more renewable energy power plants for the next 1 h to 24 h, with a typical time resolution of 15 min or 1 h

Note 1 to entry: In some documents the expression "ultra-short-term power forecasting" or "intra-day power forecasting", is used with a similar meaning.

Note 2 to entry: The expression "6-hour ahead forecasting" or similar can be used.

3.5.3
day-ahead power forecasting
active power or electricity output estimate of one or more renewable energy power plants for the next 24 h to 72 h, starting from 0 hr next day with a typical time resolution of 15 min or 1 h

Note 1 to entry: In some documents the expression "short-term power forecasting", is used with a similar meaning.

Note 2 to entry: The expression "2-day ahead forecasting" or similar can be used.

3.5.4
week-ahead power forecasting
active power or electricity output estimate of one or more renewable energy power plants for the next week or weeks, starting from 0 hr next day with a typical time resolution of 15 min or 1 h

Note 1 to entry: The expression "2-week ahead forecasting" or similar can be used.

3.5.5
deterministic power forecasting
power forecasting with certain information for a specified future time scale, usually taking the form of active power output

3.5.6
probabilistic power forecasting
power forecasting with uncertainty information for a specified future time scale, usually taking the form of probability density function or quantiles of the distribution

3.5.7
ramp forecasting
power forecasting for the ramp event of renewable energy generation in the future, which is considered to be occurring if the magnitude of the increase or decrease is greater than a predefined power ramp threshold value

3.6 Terms and definitions for grid compliance test and assessment

3.6.1
grid compliance
electrical behaviour of renewable energy power plant meeting specific technical requirements in grid codes given by power system operators, regulators or authorities

3.6.2
grid adaptability
continuous operation capability of renewable energy power plant during grid disturbance, such as voltage deviation, frequency deviation, voltage unbalance, voltage fluctuation and flicker, harmonics

3.6.3
model validation
procedure to validate some specifics of a simulation model against the test results, for example, a predefined set of model parameters

3.6.4
type test
type testing
action of carrying out tests for a given renewable energy generating unit type according to specified procedures

3.6.5
plant test
plant testing
action of carrying out tests for renewable energy power plant according to specified procedures

3.6.6
certification
third-party attestation related to products, processes, systems or persons

Note 1 to entry: Certification of a management system is sometimes also called registration.

Note 2 to entry: Certification is applicable to all objects of conformity assessment except for conformity assessment bodies themselves, to which accreditation is applicable.

[SOURCE: IEC 60050-902:2013, 902-04-05]

3.6.7
commissioning
activities undertaken to prepare a system or product prior to demonstrating that it meets its specified requirements

[SOURCE: IEC 60050-821:2017, 821-12-09]

3.6.8
surveillance
systematic iteration of conformity assessment activities as a basis for maintaining the validity of the statement of conformity

[SOURCE: IEC 60050-902:2013, 902-05-01]

3.6.9
inspection
examination of a product design, product, process or installation and determination of its conformity with specific requirements or, on the basis of professional judgement, with general requirements

Note 1 to entry: Inspection of a process may include inspection of persons, facilities, technology and methodology.

[SOURCE: IEC 60050-902:2013, 902-03-03]

3.7 Terms and definitions for scheduling, dispatching and market

3.7.1
power system participants

3.7.1.1
system operator
network operator
party responsible for safe and reliable operation of a part of the electric power system in a certain area and for connection to other parts of the electric power system

Note 1 to entry: In some countries, "network operator" is not the same as "system operator". In those countries, the system operator is responsible for dispatching generation, while the network operator (network company) operates the network, including technical availability and maintenance.

[SOURCE: IEC 60050-617: 2009, 617-02-09, modified – Note 1 to entry is added]

3.7.1.2
transmission system operator
transmission network operator
TSO
party operating a transmission system

[SOURCE: IEC 60050-617: 2009, 617-02-11]

3.7.1.3
distribution system operator
distribution network operator
DSO
party operating a distribution system

[SOURCE: IEC 60050-617: 2009, 617-02-10]

3.7.1.4
plant operator
enterprise responsible for the operation of the renewable energy power plant, either through ownership or contractual obligations

3.7.2
generation unit schedule
representation of the planned output power as a function of time within a specified time interval

Note 1 to entry: Typically, the generating unit schedule is approximated by a given set of values, e.g., output-power values averaged over sequential time intervals each of which has a duration of a quarter of an hour.

[SOURCE: IEC 60050-617: 2009, 617-03-11]

3.7.3
utilization of renewable energy

3.7.3.1
plant availability
ratio of the total number of hours during a certain period, excluding the number of hours that the renewable energy power plant could not be operated due to maintenance or internal fault situations, to the total number of hours in the period, expressed as a percentage

3.7.3.2
resource availability
ratio of the total number of hours during a certain period, excluding the number of hours that the renewable energy power plant could not be operated due to insufficient resources, to the total number of hours in the period, expressed as a percentage

3.7.3.3
production availability
ratio of the total number of hours during a certain period, excluding the number of hours that the renewable energy power plant could not be operated due to maintenance, internal fault situations or insufficient resources, to the total number of hours in the period, expressed as a percentage

3.7.4
available power
maximum possible power a renewable energy generating unit or power plant can produce taking into account equipment failure, defects, maintenance and other obstructions

Note 1 to entry: The corresponding integral power in a certain interval is available electrical energy.

3.7.5
curtailment
reduction of the active power output of renewable energy generating units or power plants below the maximum which could be fed into an electric power network in the prevailing conditions

3.7.6
curtailed power
difference between available power and actual power of renewable energy generating units or power plants

3.7.7
curtailment proportion
ratio of curtailed electricity to the available electricity of renewable energy generating units or power plants in a certain interval

3.7.8
full-load hours
FLH
utilization time
installed capacity usage time
quotient of electrical energy produced in a certain period (typically a year, 8 760 hours) and the installed power of renewable energy generating units or power plants, expressed in hours

3.7.9
electrical energy exchange
electricity exchange
marketplace for buying and selling electric power and electric energy to be delivered during a given time interval, with transparent and non-discriminatory pricing conditions for all authorized participants and with legal independence from the buying and selling business entities

EXAMPLE Different markets comprise the future market, the day-ahead market and the intraday market which have different timespans to delivery.

[SOURCE: IEC 60050-617: 2009, 617-03-01, modified – the original term "energy exchange" is changed to "electrical energy exchange" or "electricity exchange", and example is added]

3.7.10
market clearing price
determined price of an auction at which a maximum transaction volume according to the given sell and buy orders can be calculated

3.7.11
future market
electrical energy exchange where market participants trade standardized futures contracts which define quantities of electricity at a given price for delivery at a specified time in the future

3.7.12
spot market
electricity market in which electricity contracts are traded for short term delivery

Note 1 to entry: Both day-ahead and intraday markets are spot markets.

3.7.13
day-ahead market
electricity market in which electricity contracts are traded for delivery on the following calendar day

3.7.14
intraday market
electricity market in which electricity contracts are traded for delivery a few hours in advance

3.7.15
balancing market
electricity market in which real options for active power increase and decrease are traded with different activation times

Note 1 to entry: In balancing market there is usually an energy payment if the option is activated and a capacity payment for the contracted power.

3.7.16
ancillary services
services necessary for the operation of an electric power system provided by the system operator and/or by power system users

Note 1 to entry: System ancillary services may include the participation in frequency regulation, reactive power regulation, active power reservation, etc.

[SOURCE: IEC 60050-617: 2009, 617-03-09]

3.7.17
feed-in tariff
FIT
regulated price for electrical energy fed into the grid which is often used in support schemes for renewable energy and that is fixed over a long time interval of similar length as the life time of the electric generator

Note 1 to entry: Feed-in tariffs pose an incentive to invest in different types of generation and they are therefore cost-reflective, providing long-term income certainty and reduced risk.

Note 2 to entry: Feed-in tariffs often include a tariff depression, a mechanism that decreases the tariff for newly built generators over time. Enhanced digression schemes have a feedback loop to the development of investment expenses or the rate of new installations.

3.7.18
net metering
practice of measuring with a single metering device, at user's point of supply, the difference between the energy injected into the power system and the energy drawn out from the power system

Note 1 to entry: Net metering is normally used for small generation facilities.

[SOURCE: IEC 60050-617: 2009, 617-04-07]

3.7.19
demand side management
DSM
process that is intended to influence the quantity or patterns of use of electric energy consumed by end-use customers

[SOURCE: IEC 60050-617: 2011, 617-04-15]

3.7.20
demand response
DR
action resulting from management of the electricity demand in response to supply conditions

[SOURCE: IEC 60050-617: 2011, 617-04-16]

3.8 Miscellaneous terms and definitions

3.8.1
low voltage
LV
a set of voltage levels used for the distribution of electricity and whose upper limit is generally accepted to be 1 000 V for alternating current and 1 000 V or 1 500 V for direct current

[SOURCE: IEC 60050-601:1985 601-01-26, modified − threshold of low voltage for direct current is added]

3.8.2
high voltage
HV
1) in a general sense, the set of voltage levels in excess of low voltage

2) in a restrictive sense, the set of upper voltage levels used in power systems for bulk transmission of electricity

[SOURCE: IEC 60050-601:1985, 601-01-27]

3.8.3
medium voltage
MV
any set of voltage levels lying between the lower limit of high-voltage and a specified higher value

Note 1 to entry: The boundaries between medium- and high-voltage levels overlap and depend on local circumstances and history or common usage. Nevertheless the band 30 kV to 100 kV frequently contains the accepted boundary.

[SOURCE: IEC 60050-601:1985, 601-01-28, modified – the upper range of medium voltage is specified]

3.8.4
(electronic) (power) converter
operative unit for electronic power conversion, comprising one or more electronic valve devices, transformers and filters if necessary and auxiliaries if any

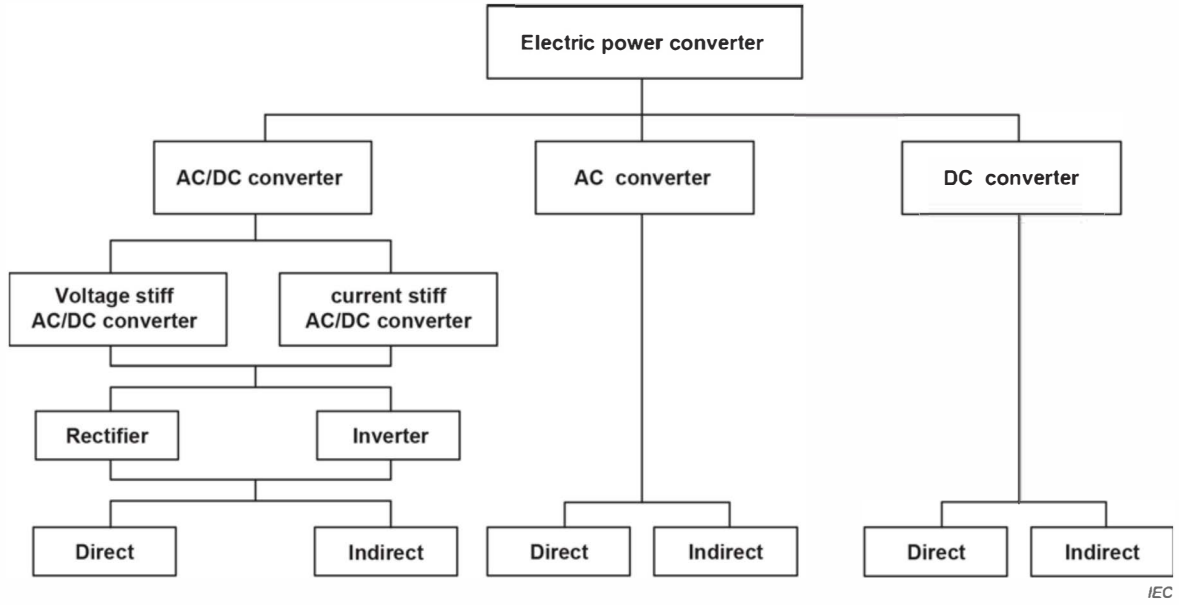


Figure 1 – Examples of basic electronic power converters

Note 1 to entry: See Figure 1.

Note 2 to entry: In English, the two spellings "convertor" and "converter" are in use, and both are correct.

[SOURCE: IEC 60050-551:1998, 551-12-01, modified – the word "convertor" is deprecated in this document]

3.8.5
inverter
electric energy converter that changes direct electric current to single-phase or polyphase alternating currents

[SOURCE: IEC 60050-151:2001, 151-13-46]

3.8.6
inverter-based generator
IBG
generator connecting to the electric power network via an inverter

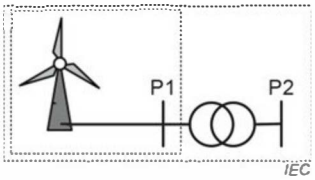
4 Acronyms and abbreviations

BPS	bulk power system
CSCR	composite short-circuit ratio
DER	distributed energy resources
DG	distributed generation
DR	demand response
DSM	demand side management
DSO	distribution system operator
EENS	expected energy not supplied
EMT	electromagnetic transient
FIT	feed-in tariff
FLH	full load hours
FRT	fault ride-through
HV	high voltage
HVDC	high voltage direct current
IBG	inverter-based generator
LFO	low-frequency oscillation
LV	low voltage
MV	medium voltage
PCC	point of common coupling
PGUC	point of generating unit connection
POC	point of connection
RE	renewable energy
REG	renewable energy generation
REGU	renewable energy generating unit
RMS	root mean square
ROCOF	rate of change of frequency
SCR	short-circuit ratio
SCRIF	short-circuit ratio with interaction factors
SSO	sub-synchronous oscillation
SSR	sub-synchronous resonance
TSO	transmission system operator
OFRT	over-frequency ride-through
OVRT	over-voltage ride-through
UFRT	under-frequency ride-through
UVRT	under-voltage ride-through
VPP	virtual power plant
VRE	variable renewable energy
VSG	virtual synchronous generator
VSM	virtual synchronous machine
WSCR	weighted short-circuit ratio

Annex A
(informative)

Illustration of unit, plant, cluster and kinds of points

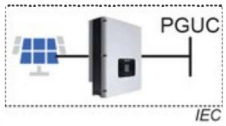
Renewable energy generating units may have different forms according to the types of renewable energy sources, rated voltage and topology design. Figure A.1 shows six typical forms of generating units in wind power plants and photovoltaic power plants.



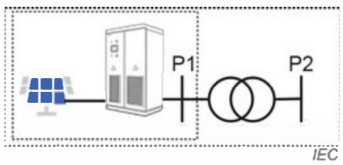
a) generating unit in a wind power plant with low voltage wind turbine and two-winding boost transformers

NOTE If the PGUC is defined at P1, the boost transformer belongs to the power collection system. If the PGUC is defined at P2, the boost transformer belongs to the generating unit.

b) generating unit in a wind power plant using a wind turbine with medium rated voltage

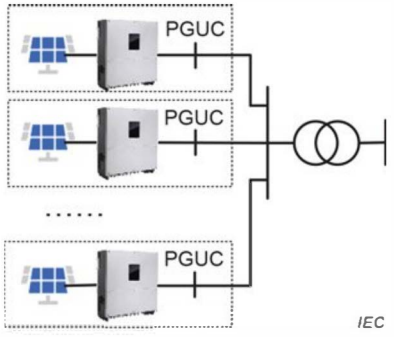


c) generating unit of a residential photovoltaic power plant using a residential inverter which is directly connected to the low voltage network

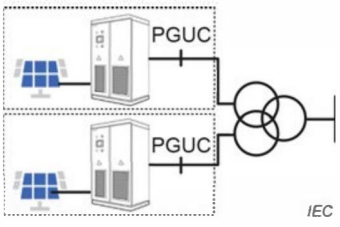


d) generating unit in a photovoltaic power plant using a central inverter and two-winding boost transformers

NOTE If PGUC is defined at P1, the boost transformer belongs to the power collection system. If the PGUC is defined at P2, the boost belongs to the generating unit.



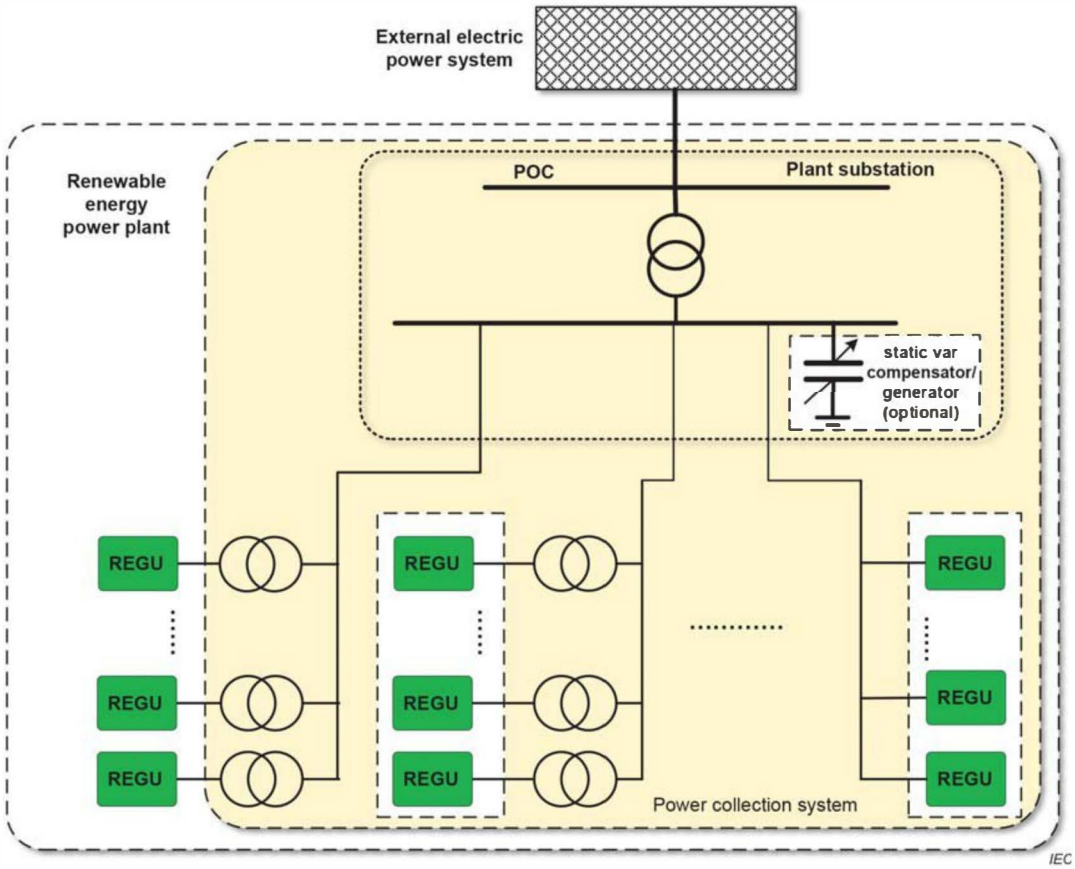
e) generating units in a photovoltaic power plant using tens of string inverters and two-winding transformers



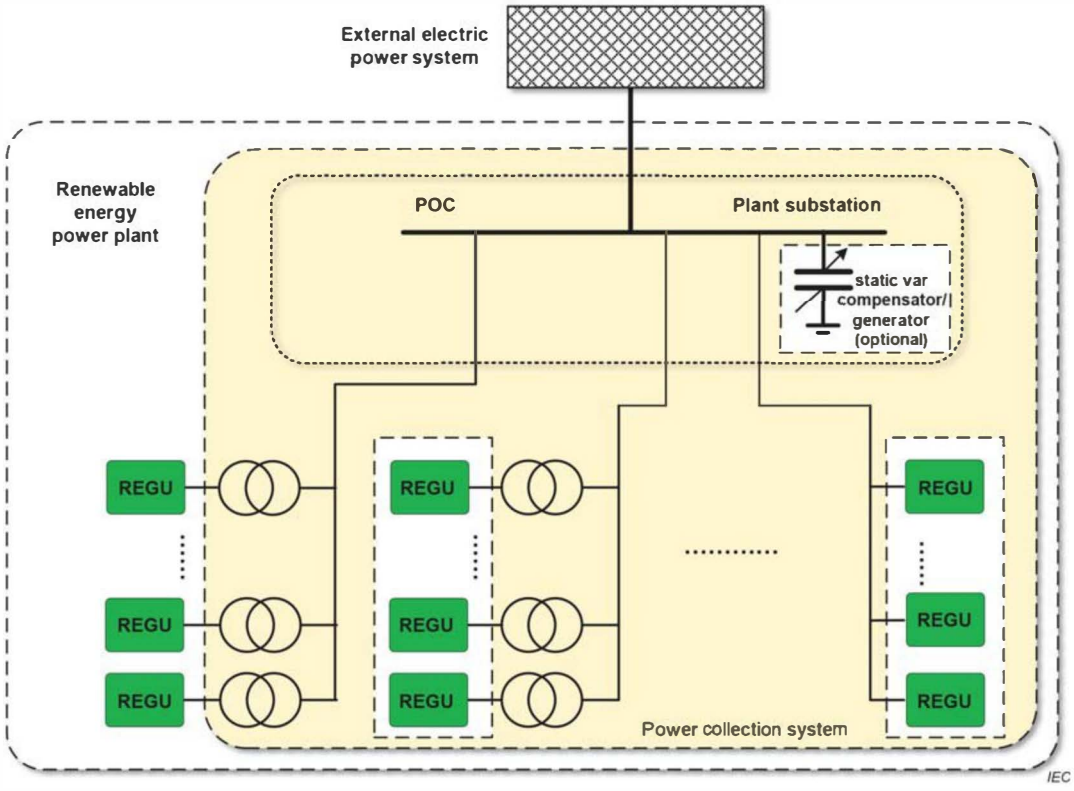
f) generating units in a photovoltaic power plant using two central inverters and one boost transformer with split windings

Figure A.1 – Typical forms of renewable energy generating units

A renewable energy power plant usually includes one or more renewable energy generating units, a plant substation (transformer substation or switching substation) and necessary overhead lines or cables, which all belong to the power collection system. Normally, reactive power compensation systems equipped inside the plant substation to help maintain the voltage stability, such as SVC or SVG, are not a part of power collection system. Figure A.2 shows two typical forms of a renewable energy power plant.



a) The plant substation is a transformer substation



b) the plant substation is a switching substation

Figure A.2 – Typical forms of renewable energy power plants

Figure A.3 shows the typical form of several renewable energy power plants connected to the power network via a substation. These power plants form a cluster. The PCC point will be in different places according to the owner of the substation.

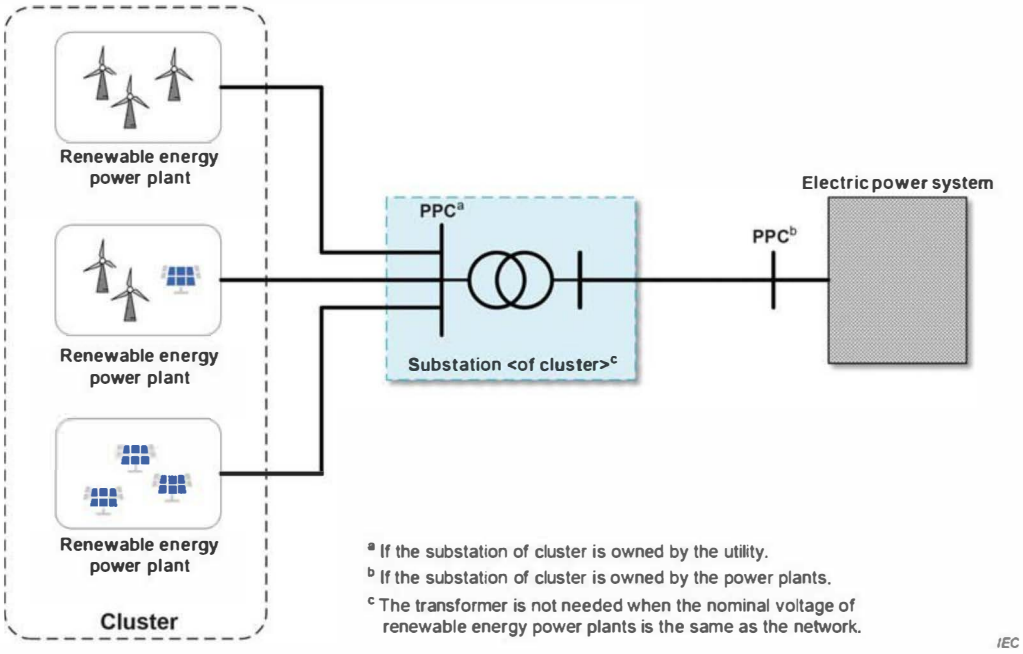


Figure A.3 – Cluster of renewable energy power plants

Index of terms

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