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Annex O - DER Plant Controller

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Sommario

Il presente documento è la traduzione in inglese dell'Allegato O della Norma CEI 0-16:2022-03.
Si evidenzia che il CEI non ha pubblicato una versione in inglese della Norma CEI 0-16. Questa traduzione del solo Allegato O è stata predisposta dal CT 316 per essere utilizzata come documento di lavoro nell'ambito di gruppi di lavoro CENELC o IEC.

Abstract

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It should be noted that the CEI has not published an English version of CEI 0-16. This translation of Annex O only has been prepared by CT 316 for use as a working document within CENELC or IEC working groups.

PREMESSA

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FOREWORD

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Annex O
(normative)

DER Plant Controller

O.1 Generals

The main object of this Annex O is the “Distributed Energy Resource” Plant Controller (hereinafter CCI), i.e. that apparatus, specifically defined in Clause 1 below (General Description of the CCI), whose main tasks are:

- coordinate the operation of the different elements of the plant so that the plant itself operates, as a whole, in such a way as to satisfy both the requirements of the DSO at the point of connection to the grid (hereafter POC) and those of any other operators (Control Function)
- collect useful information from the plant in order to permit the monitoring of the grid and transfer it towards the DSO (Data Exchange hereafter)

In this way, CCI allows the plant to be presented to the DSO or other operator as a single "equivalent generator" seen from the POC, without, however, precluding the observability of the different elements of the plant.

The purpose of this work is the definition of the functional specification of CCI by establishing the minimum requirements that CCI shall meet in accordance with the requirements of:

- CEI 0-16 standard, taking into account the conditions that exist today regarding the status of "smart grids" on MV distribution networks;
- ARERA Resolution 36/2020/R/EEL regarding the information exchange between the generating plants and TSO, an exchange that shall take place primarily through the DSO that manages the grid to which the same generating plants are connected (which may also use a third-party DSO to perform the service[183], as specified in Annex A.6 to TSO Grid Code, in accordance with EU Regulation 2017/1485 (hereinafter SOGL Regulation - System Operation Guidelines).

Precisely in order to comply with the dictates of the SOGL Regulation in accordance with the provisions of ARERA Resolution 36/2020/R/EEL, the functional specification of CCI in terms of performance is developed as follows

- “mandatory" functional performance, regarding the information exchange between producer and DSO (observability);
- “optional" functional services, inherent to voltage control and power limitation at the plant's POC;
- “discretionary" functional services, regarding the plant's participation in the Dispatching Services Market, optimal management of the plant, etc.

The timing according which also the functions that are currently optional and/or discretionary become mandatory will be established later by ARERA with appropriate resolutions.

In terms of hardware, CCI can be built as an integrated device in which the control functions are integrated with the monitoring functions (observability) or alternatively in modular form with the monitoring function implemented as a sub-component of the CCI.

The functions of CCI may also be integrated in one of the other electronic devices) constituting the plant, provided that it is possible to test the functions of these devices in accordance with the indications of this Annex.

(183) The resolution provides that DSO may also use a third-party DSO to perform the data exchange service. If the competent DSO explicitly renounces this option, including the justified impossibility of using a third-party DSO, data must be sent directly to TSO. However, this alternative is to be considered as a solution of last resort.

Annex O specifies the CCI in an integrated form in which, however, the functions associated with observabilitỳ of the network shall be implemented obligatorily and with priority over the other functions.

In any case, in formulating the prescriptions of this Annex, no constraints have been placed on the possibility of extending the functional performance of the CCI in the future and, where already feasible, the possibility of a more extensive use of the same has been made explicit in the text, as regards both the interface with the DSO or other possible operators and the optimal management of the generating plant

With reference to the management of the interface, it seems most reasonable, in the perspective of the development of smart grids and in the presence of a standard EN 61850 communication channel, to already foresee in this specification the possibility for CCI to be prepared to make the best use of this potential.

For example, the possibility of receiving configuration settings on CCI remotely via the communication channel instead of only configuring them locally.

The same reasoning can be applied for other functions that may be conveyed in the future through the communication channel: these functions, when required, will be appropriately prescribed in CEI 0-16 and Annex O will be consequently updated, where necessary, to adapt the functional requirements of CCI to it.

On the other hand, the requirements for certain discretionary functional services are already present in this document, in particular those necessary to also allow distributed generation access, on an aggregated basis, to the Market for Dispatching Service (MSD) through an aggregator (Balance Service Provider - BSP) in accordance with the latest ARERA guidelines as expressed in Resolution 300/2017/R/EEL, as supplemented by subsequent Resolutions 422/2018/R/EEL and 153/2020/R/EEL.

These will then have to be updated and/or supplemented at the end of the experimentation started by TSO in accordance with AEEGSI Resolution 583/2017/R/EEL, which provides for an initial opening of distributed generation to MSD, through pilot projects.

This Annex is in any case complete in order to support the experimentation of the pilot projects.

As far as the optimal management of the plant is concerned (another “ discretionary ” functional performance), this is, instead, left with complete freedom to the Producer , who will be able to develop the architecture of CCI according to his own needs, with the not secondary result of also being able to achieve a more profitable use of CCI (and consequently of the response of its own plant) with respect to the control prescriptions now required by the CEI 0-16 Standard. Without forgetting that already today preparing a more sophisticated architecture of both CCI and the plant internal communication network is a necessary investment to be able to participate in the dispatching service tomorrow.

Optimal plant management could also be implemented not only through the control of the generating/storage units, but also with the contribution of the plant load. This last possibility could become useful in the perspective of new functions involving, for example, the modulation of loads, according to models inspired by UVAM, already present in ARERA Resolution 300/17/R/EEL and subsequent Resolutions 422/2018/R/EEL and 153/2020/R/EEL.

The subject of loads is not dealt with in Annex O, as it is still under study.

The prescriptions contained in this Annex O therefore refer to a CCI that coordinates, controls and monitors only the generating and storage units.

This Annex also regulates the cybersecurity requirements for the hardware component [(184)].

(184) Cybersecurity requirements relating to communication from the outside to CCI and from CCI to the outside are the subject of Annex T.

“Cybersecurity” issues shall be duly taken into account by those responsible for the communication channels and the installation. The designer of CCI shall prepare the equipment in such a way as to be able to handle what is specified on this subject both in this Annex and Annex T of CEI 0-16.

O.2 Scope

This Annex applies to:

- new connections of generating plant with a total rated power equal to or greater than 1000 kW[185] connected to the MV grid (i.e. – Significant Grid User – SGR[186] belonging to the standard perimeter[187]).
- new connections of installations connected to the MV grid participating in dispatching services, whatever their total power.

Conditions and modalities for the application of this Annex to connections of plants with a power of less than 1 MW belonging to the "extended perimeter" [188] as well as to connections of existing installations ("retrofit") will be established by ARERA.

The prescriptions of this Annex are divided into mandatory, optional and discretionary, as better described in Clause O.6 below.

The prescriptions of this Annex apply and are currently mandatory only for the Monitoring and information exchange (Data Exchange) functions as required by ARERA Resolution 36/2020/R/EEL and as specified in Clause O.8 below.

For the purposes of this Annex, installations equipped with generating units, regardless the primary source, and storage systems are considered to be generating plants.

In the case of installations equipped with both generating/storage units and loads, this Annex is prescriptive only for the control of the generating and storage units.

Modulating loads and power factor correction devices, if present in the system, may also be managed by CCI in cases where the User deems it useful for optimal management of the plant.

This is not in the scope of this Annex.

CCI shall not perform any protection functions, neither that of general protection nor that of interface protection, nor shall it perform the protection functions of the generating units. All these functions shall be performed by autonomous devices as specified in CEI 0-16 this standard (Subclauses 7.5.12, 7.7.2, 8.5.12, 8.8.1, 8.8.5, Annex D, Annex E, Annex Z).

Similarly, in the presence of over-frequency or under-frequency transients originating on the grid, CCI shall NOT implement any of the regulation actions envisaged in 8.8.6.3.2 ("Limitation of active power for over-frequency transients originating on the grid") and 8.8.6.3.3 ("Increase of active power for under-frequency transients originating on the grid") of the CEI 0-16.

(185) 1000 kW as the sum of production and storage units.

(186) As defined by the SOGL regulation and listed in clause 2 of the RfG regulation.

(187) As defined in ARERA Resolution 36/2020/R/EEL.

(188) Sub-set of production plants with a capacity of less than 1 MW that will be appropriately chosen in a second phase on the basis of geographical and size criteria (ARERA Resolution 36/2020/R/EEL).

O.3 General description of the CCI

The CCI is an apparatus whose main tasks are:

- Carrying out the monitoring function of the plant with the aim of collecting information from the plant and the generating/storage units useful for the "observability" of the grid[189] (monitoring functionality).
- Coordinating the operation of the various elements that make up the system, so that the system as a whole operates in such a way as to meet the requirements of standard CEI 0-16, reported at the point of connection to the grid (POC), in compliance with the capabilities prescribed by the same standard for the individual generating and storage units (control and command functions);
- Enable the exchange of information between the plant and DSO (and between the plant and TSO via DSO to which the plant is connected) using the IEC 61850 communication standard and data transmission networks, as well as between the plant and any other authorised actors, in accordance with the methods governed by this Annex and Annex T to CEI 0-16 (data exchange functions).

CCI achieves the objective of presenting the plant as a whole consisting of a single equivalent generator connected to DSO network in POC, which takes into account the characteristics of the individual generating and storage units as well as the plant internal network. However, the observability of the different elements constituting the plant is not precluded.

Furthermore, CCI is also the only interface point for the exchange of information between the generating storage units constituting the plant and DSO.

In the presence of a communication channel between DSO and the User, CCI makes available to DSO characteristics, signals and measurements relating to the underlying plant and, at the same time, can receive commands and parameters sent by DSO to the plant, using for communication the IEC 61850 Standard, suitably "securitised" in accordance with the IEC 62351 series as defined in Annex T.

In the event that the plant participates in MSD services via BSP intermediaries, such intermediaries may acquire information from the plant and send commands to the generating/storage units via CCI only, irrespective of the way in which the information is transmitted between the BSP and the plant (see O.13.1.3 below).

O.4 Main features of CCI

CCI shall be able to acquire and process all the information necessary for the management of interfaces related to:

- DSO;
- the elements of the plant
- any additional authorised Actors [190]

according to the description in O.3

From an executional point of view, at least the following “functional units” can be identified in CCI:

- unit for information exchange with DSO and other authorised actors
- unit of acquisition of quantities at POC DSO (measurements and signals)
- units for processing purpose

[189] This information is sent via DSO to which the installation is connected, to TSO for the secure management of the transmission system.

[190] The User and the Aggregator, if any.

- unit for control of installation elements(191)
- unit for information exchange with installation elements(192)
- storage unit (data logger).

The separation into functional units is purely indicative: in the design of CCI they may be all or partially integrated with each other, just as they may not all be developed at the same time, in relation to the priorities of the functions that CCI shall make active according to the provisions of the ARERA resolutions.

The functions of CCI may also be integrated as an additional functionality in one of the other apparatuses of the plant (e.g. controller of a generating unit operating as Master for all the other units, centralised control system, protection devices, etc.) as long as their respective functionalities are not compromised.

Other functional units useful for the optimal management of the system may be implemented in CCI. Requirements concerning these functional units are, as already stated, outside the scope of this Annex.

O.5 Modes of operation of CCI

CCI is designed to perform monitoring and data exchange functions as well as control, and command functions.

In its monitoring-only mode of operation, CCI does not perform any control actions on the underlying plant elements.

In contrast, CCI, in its control functionality, shall perform control actions on the underlying plant elements.

In this functionality, CCI shall provide an autonomous control mode and a slaved control mode as alternatives to each other: the slaved mode has priority over the autonomous mode.

In the autonomous control mode, CCI shall implement the control functions provided for by CEI 0-16, using the parameters (by default) established by the same Standard for each type of function or defined by DSO at the same time as the “Operation Rule” on the basis of the characteristics of the specific plant.

The function to be implemented and the relevant parameters shall be set by the User and/or designer of the plant by acting on CCI via a local configuration terminal or via a remote user terminal.

In the slaved control mode, CCI shall operate according to the control functions communicated by DSO via a logical communication channel according to EN 61850 and using the parameters for such also sent by the DSO via the same channel.

In the case of participation in the services of MSD, the corresponding functions of CCI shall operate in accordance with the priorities defined for the individual functions (see O.11 below), according to with the requirements of the BSP, which will also communicate with CCI via a logical communication channel.(193)

In the event that there is no communication channel between CCI and the external operators, the functions defined as “slaved " shall be able to be configured and made operational directly on CCI in the autonomous operation mode.

(191) The presence of the installation element control unit is strictly related to the functions to be performed by CCI.

(192) The information exchanged with the installation elements depends on the characteristics of the plant itself and of the functions to be performed by CCI.

(193) The communication standard between CCI and the aggregator can be defined after the testing of pilot projects.

Monitoring and/or control of CCI through the local terminal by the user shall be performed using communication channels that are physically independent and logically unrelated to the communication channel with external operators.

More complete requirements for communication interfaces are given in Subclause O.13.1.

O.6 Functional performance

As already mentioned, CCI shall present three types of functional performance:

PF1. mandatory, i.e. functionalities that shall be always present in every type of CCI;

PF2. optional, i.e. additional functionalities that the CCI shall be prepared to perform in support of the electrical system, in the manner and within the timeframe indicated by ARERA;

PF3. discretionary, i.e. functionalities whose implementation depends on the initiative of the producer

The mandatory PF1 services relate to monitoring and data exchange services; the optional PF2 functionalities relate to the services for limiting the power fed in and voltage control at the POC; the discretionary PF3 services relate to optimised installation management and participation in the Dispatching Services Market, as extensively described in the relevant paragraphs below. Anything in this Annex not specifically associated with the optional PF2 or discretionary PF3 features shall be deemed mandatory.

As referred to in Clause O.2, the types of plants and the conditions to which the PF1 and PF2 functional services shall be applied as well as the conditions to which the PF3 functional services may be applied with regard to participation in the Dispatching Services Market are established by ARERA.

O.6.0 Functional performance PF1 (mandatory)

For the purpose of knowing the status of the plant for the safe operation of the electrical network , CCI shall make available a set of information (measurements and statuses) relating to the plant , in accordance with the requirements of the TSO Grid Code, Annex A.6, and with CEI 0-16 clause 10, as specified in the following Subclauses "O.8.3", "O.8.4" and "O.8.6").

The characteristics of CCI and of the elements constituting the plant, as well as of the plant internal communication network, shall be adequate to ensure the, accuracy, updating frequency and ageing prescribed in the aforementioned documents.

O.6.1 Functional performance PF2 (optional)

CCI shall ensure the following minimum functional performance:

- participation of the plant in voltage control the POC, in accordance with 8.8.6.2 ("Participation in voltage control") of CEI 0-16 (see following clauses "O.8.2");
- participation of the plant in active power limitation, in accordance with Clauses 8.8.6.3.1 ("Active power limitation for voltage values close to 110% of Un") and 8.8.6.3.4 ("Active power limitation on external command from the DSO") of standard CEI 0-16 (see following Clauses "O.8.2", "O.9.2").

All these functional performance shall refer to the quantities at POC and operate in compliance with the capabilities of the elements of the plant.

O.6.2 Functional performance PF3 (discretionary)

CCI can also implement the following PF3 services:

- services for plant management;
- services for participation in the dispatching services market.

These discretionary functional services shall also refer to the quantities at the POC and operate in compliance with the capabilities of the plant elements.

O.6.2.1 Services for plant management

The functional performances for plant management are:

- start-up and re-starting of the plant with a specified gradient of active power output as per 8.8.4 (of CEI 0-16 (see O.10.1 that follows);
- reconnection of the plant after disconnection from the grid, at stabilised frequency and voltage (see O.10.2. below);
- energy-optimised operation of the plant or on the basis of other criteria selected by the user and/or system designer (see the following O.10.4).

O.6.2.2 Services for participation in the Dispatching Services Market [194]

In view of the possible participation in the Market for Dispatching Services (MSD) of plant connected to the MV grid, CCI may be developed with additional functions designed to allow the BPS to use plant resources to meet the requirements of the Market itself.

In order to provide support to the Aggregating Entities (BPS), an additional function able to receive and process an "Active Power Set-Point" command shall be implemented in CCI (see O.9.1 below, as well as the following O.8.2, O.8.5), conveyed via an appropriate logical communication channel between Aggregators [195] and CCI.

The services necessary for Dispatching Services are:

- Balancing Services;
- Tertiary frequency Power control
- Secondary frequency Power control

Each of the three services has specific requirements, described in TSO Grid Code.

CCI, plant elements, communication network between CCI and plant elements, communication channel (direct or indirect) between CCI and BPS shall all be designed in order to meet the response time requirements of the active power set-point commands related to the market services in which the generating plant intends to participate[196].

Depending on the dynamic performance of the elements of the plant the plant itself may be suitable and therefore authorized to support the Aggregator (BSP) for all three services or only for some of them.

The validation of the suitability of the plant to provide certain services shall take place through appropriate tests not covered by this Annex.

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[194] The requirements for participation in MSDs may eventually be extended to what is outlined in 5.2.2 of CEI 0-16 "Operation of sections of the MV distribution network in island situations ".

[195] This channel may be physically realised through a public telecommunication service provider or channelled through the communication service realised by the Distributor or other. ARERA will rule on this matter.

[196] To date, only generation and storage units.

CCI shall also have the functional capability to receive and activate the reactive power set-point control (see O.10.3.1, “Reactive Power Set-Point Control on external I Command).

O.7 CCI Overview

O.7.1 Interface Scheme

Figure 1 gives a simplified overview of CCI correlated with the various interfaces with which it shall communicate to exchange information and receive or transmit commands.

Future evolutions of the entire system with further functional performance also concerning loads are also envisaged in the general diagram.

The Figure is purely indicative and is used to contextualise the functions of CCI in relation to the other elements with which it shall or can interface. This Figure functionally represents the individual "information exchanges" ("logical services" hereafter) of CCI; it does not define either the individual physical interfaces or their characteristics.

In this respect, see the following Subclause O.13.1 (197).

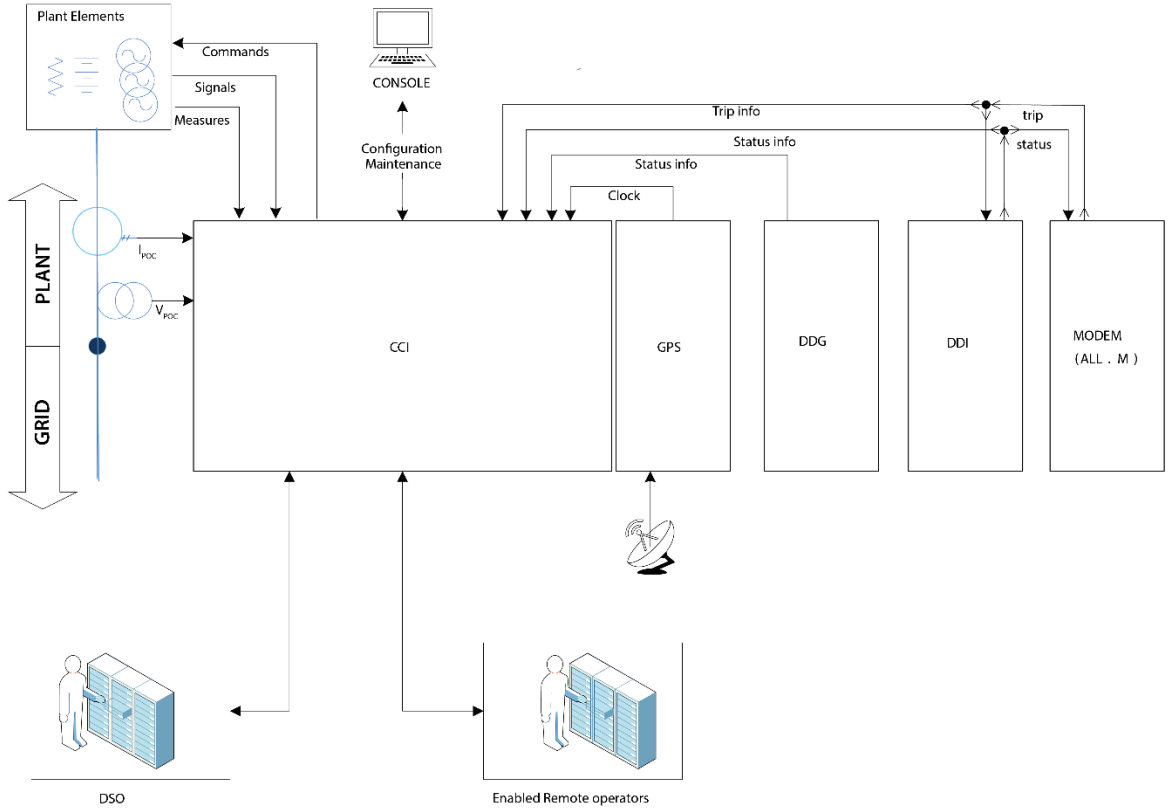

Figure 122 – General scheme of the CCI system with its functional interfaces

O.7.2 Principle diagram of CCI control function

Figure 2 shows a schematic diagram of CCI, in order to illustrate in a simplified manner how it shall operate in its control functions.

The diagram is intended as purely indicative.

(197) In general, communication services may use the infrastructure of public communication service providers. For cybersecurity reasons, there must be no exposed communication over the Internet; communication must therefore always and only take place through a private network (VPN) through which the information of interest to the various actors must pass. They must be provided with an appropriate “authentication certificate”, validated by a server accessible from the VPN. In the perspective of smart grid development, the possible presence of a direct physical communication channel between DSO and Producer must also be considered.

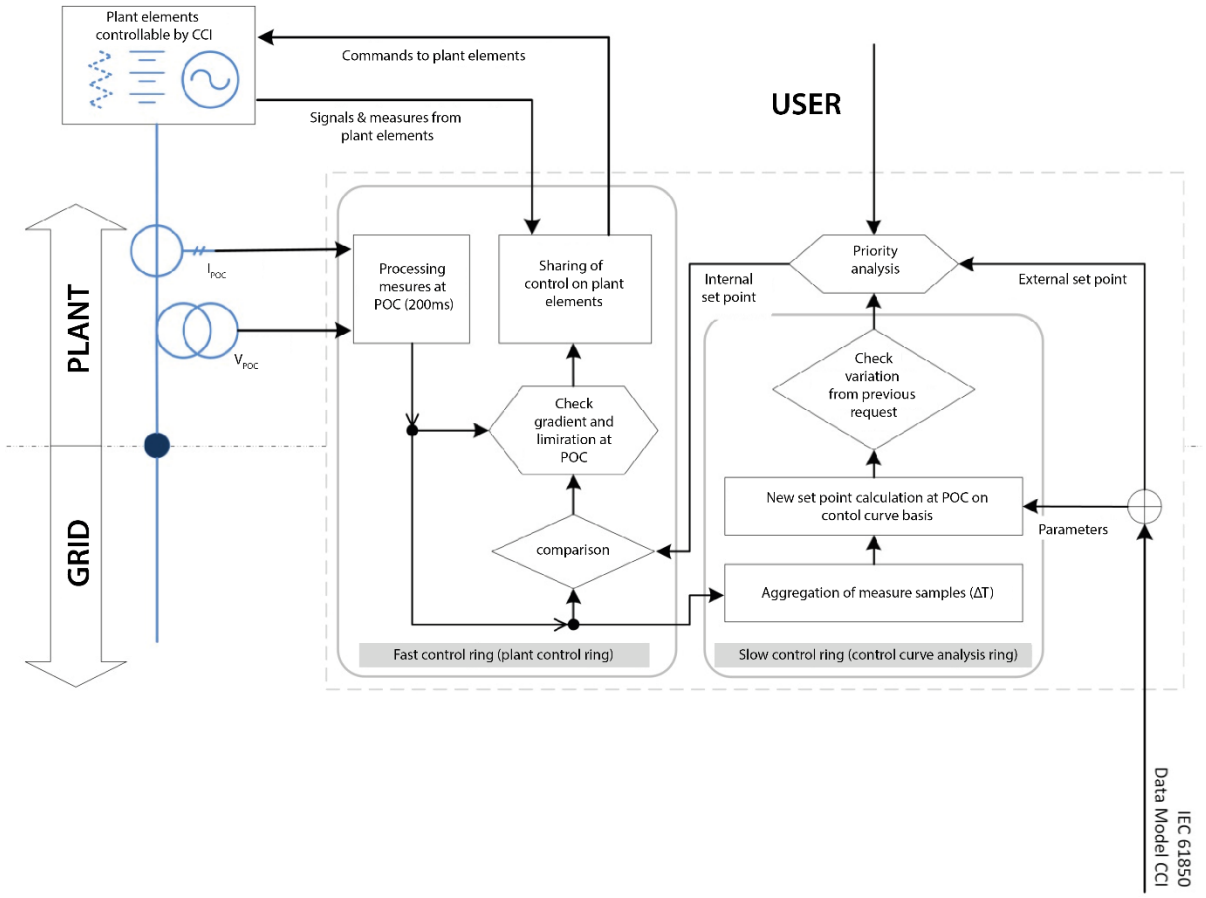

Figure 123 – Block diagram of control rings to be implemented in CCI

The diagram shows two control rings:

- "fast control " ring (or "plant control " ring)
- “slow control ” ring (or "control curve analysis" ring)

The "*fast control*" ring is to be understood as that part of the control system which defines the specific operating point of each individual plant element coordinated by CCI (hence the synonym "*plant control ring*"), in order to reach the overall operating point required from the plant at POC (the "*expected operating point*" identified by the "internal *set-point*" in the Figure).

This "fast control" ring shall compare the working point of the plant at the POC with the "*expected working point*" and shall correct deviations resulting from the dynamics of the system or from variations in the network conditions, by means of coordinated modification of the working point of the individual plant elements, in compliance with their respective capabilities and with the limits imposed by the standard regarding the values and the power gradient at POC, if any.

The "*expected operating point*", i.e. the internal set-point, is conveyed to the input of the "*fast control*" ring either directly via an external command or indirectly as an output command resulting from the "*slow control*" ring calculation.

The "*slow control* ” ring, in fact, is responsible for calculating the expected working point at POC when the system is called upon to participate in the control of the MV network voltage, as prescribed by the standard in 8.8.6.2 clause through the control curves specified in Annex I (hence the synonym "control *curve analysis ring*").

The "*slow control*" ring determines a change in the expected operating point of the plant only when the deviation between the newly calculated operating point and the previous one is greater than a predefined value (*dead band'*– see the following Clause O.9).

In few words, the expected operating point which then translates into the internal set-point of the "*fast control*" ring is defined by one of the following three methods:

i. established by the User responsible for the plant through a specific active power (P) or reactive power (Q) set-point;

ii. imposed by an external set-point, again either of active power (P) or reactive power (Q);

iii. calculated by the “slow control” ring, as a set-point of Q=Q(V) or cosfi=cosfi(P).

The first two are incoming command from outside; the third is a value generated within CCI.

The selection between these three modes shall be made according to priority criteria, set out in Sub-clause O.11. below.

The new operating condition determined by the selected operating point (internal set-point) that CCI shall impose on the plant elements it coordinates (new operating points for each controlled element) shall be achieved by transmitting, via the internal communication network, suitable control signals that may be incremental (increase-decrease), absolute, percentage or p.u. (set-point, level signals, etc.) type.

Depending on the complexity of the plant (e.g. the presence of several generating units of different types - photovoltaic, wind, hydraulic, storage, etc. - and/or of different sizes) and the needs of the user (optimisation of plant operation), the new working points for the individual plant elements may be the same for all of them or specific for each of them (i.e. processed with simplified algorithms or more complex algorithms respectively) depending on the level of "intelligence" integrated in the system (see O.10.4).

These specific situations require that CCI is provided with appropriate measurements taken at the terminals of the individual plant elements coordinated by the CCI, measurements that can be acquired via the communication channel between CCI and the plant element (as shown indicatively on the diagram).

The choice of a more complex solution is left to the user and/or plant designer; with a view to the participation of the plant in future grid services it is advisable to favour immediately solutions that allow the accurate control of the individual elements coordinated by CCI.

O.7.3 Specific operating times for CCI control functions

CCI control system shall comply with the characteristic operating times as defined in the following paragraphs.

Certain values, where indicated, are issued by DSO in the “Operating Rule” and may not be changed without new instructions from DSO.

O.7.3.1 Dynamics of the “fast control” ring

The “*fast control*” ring shall coordinate the individual underlying system elements ensuring maximum settling times (Ts) [198] for the entire plant not exceeding:

- TsP = 60 s, for active power internal set point changes of any size,
- TsQ = 10 s, for reactive power internal set-point changes of any size,

[198] The values given arise from the provisions of CEI 0-16 Annex N, clauses N.7.4.1 for P and Annex I clause I.3 and Annex N clause N.6.2.3 for Q.

where the settling time Ts is to be understood as the time interval which elapses from the instant To of application of the new set-point to the instant in which the value of the quantity controlled at POC (i.e. V, P, Q, etc) falls stably within a tolerance band of ±5% with respect to the expected value.

CCI and the plant coordinated by it can be realised in such a way as to reach the expected value in less time than the maximums prescribed herein [199].

For the verification of the achievement of the expected value by the “fast control ring”, the same criteria defined in Annexes N.7.4.1 ("Verification of the settling time to a power reduction command") and N.6.2.3 ("Response time to a step change in the assigned level") of CEI 0-16 shall be used for active and reactive power respectively.

O.7.3.2 Dynamics of the "*slow control*” ring

The “*slow control*” ring, which works through “specific control curves”, shall operate with a dynamic characterised by a cycle time ΔT that shall be adjustable between 10s and 600s, by appropriately setting the operating parameters of CCI.

The default value is 60 seconds, unless otherwise prescribed by DSO in the “Operating Rule”.

The new set-point calculated at the end of the ΔT cycle, if permitted by the priority rules, shall modify the internal set-point, even if the previous value expected at POC has not yet been reached.

CCI shall be able to process external commands to modify control functions in such a way to t acquire the new parameters and process the new control curves. within the ΔT since from the reception of the command.

Change commands received at intervals shorter than ΔT are rejected.

O.7.3.3 External Set Point Dynamics

CCI shall be able to process external set-point commands so that set-point updates can be received and processed at intervals of not less than 3 s since the last processed set-point.

Update commands arriving with time intervals of less than 3s are rejected.

O.7.4 Measuring reference for control rings

The control rings shall operate from measurements developed in accordance with IEC 61557-12, with the accuracy classes defined in O.13.2.1, using the fixed block interval method (see Annex B of IEC 61557-12).

Measurements processed with a duration interval of 200ms are here referred to as M_{C200}. Measurements processed with a duration interval of ΔT (as defined in O.7.3.2) are here referred to as $M_{C\Delta T}$.

Samples referring to voltages and currents shall be sampled synchronously.

The “fast control” ring shall operate using the above-mentioned M_{C200}.

The “slow control” ring shall operate using the above-mentioned $M_{C\Delta T}$ values.

[199] If the plant participates in market mechanisms for secondary power control (see O.6.2.2), the maximum settling time for active power must allow the plant to follow the gradient prescribed by the TSO Grid Code.

These values are to be used in the “slow control” ring for both the calculation of the expected operating point and the evaluation of the lock-in and lock-out thresholds requested to enable the various control functions, where required.

For the accuracy characteristics of the measurements at the POC, see the following clause O.9.1.

For the accuracy characteristics of the measurements acquired from the individual plant elements, these, when necessary, shall be detected and used by CCI in such a way as not to degrade the overall accuracy of the control system and in any case in compliance with the minimum requirements for the monitoring functions referred to in Subclause O.8.1.

O.8 Monitoring of the plant and information exchange

O.8.1 General

In order to know the status of the plant for the safe operation of the grid, the producer shall make available a series of information relating to the plant, in accordance with the requirements of the current CEI 0-16, clause 8.10 and the provisions of ARERA Resolution 36/2020/R/EEL with reference to Annex A.6 of TSO Grid Code, as specified in the following paragraphs.

CCI shall acquire this information in its architecture and make it available, complete of identifying data of the elements [200], for transfer to the DSO via an appropriate communication channel [201] with EN 61850 protocol, in accordance with the procedures set out in Annex T of CEI 0-16.

Without the communication channel, the formats for collecting the information and the methods of transmission will be defined in the “Operating Rule”

Even in this paragraph each type of information is marked with: "mandatory (PF1)", "optional (PF2)", "discretionary (PF3)".

O.8.2 Polygonal characteristic of the plant (PF2, PF3)

In accordance with the prescriptions of the current CEI 0-16, clause 8.10, the Producer shall make available to the DSO the power performance of the various plant elements.

From this data, the following quantities are defined in the “Operating Rule” for the part of the plant that includes only the generating and storage units (excluding loads), calculated as indicated in the note below[202].

- Maximum active power absorption from the grid (P_{ass})
- Maximum grid feed in active power (P_{imm});
- Maximum capacitive reactive power (Q_{cap});
- Maximum inductive reactive power (Q_{ind}).

These values are then used to draw a conventional plant specific curve referring to the POC (“plant polygonal characteristic" - see Figure 124 below) which, basically, defines an area in which the plant will always operate, whatever its control condition.

[200] Such as POD, HW and FW version of CCI, as detailed in Annex T.

[201] The type of communication channel to DSO is established by ARERA.

[202] Is not otherwise stated by the DSO, the quantities may be calculated as a simple superposition of the effects of the individual plant elements (generating and storage units, excluding loads), considered, for each of the required quantities, acting simultaneously, each at its maximum capability.

In order to make profitable use of this polygonal characteristic, it is appropriate to establish, from the maximum values indicated above, a second conventional quantity, defined as the Maximum Apparent Power of the plant S_{max} [203], again referring to the POC, and calculated as:

$$S_{max} = \sqrt{\max(P_{imm}^2, P_{ass}^2) + max\left(Q_{ind}^2, Q_{cap}^2\right)}$$

This quantity shall be taken by CCI as the basis to which the electrical quantities expressed in per unit are related. In this way, the bi-univocal exchange of information in per unit (e.g. set-points) through the plant CCI, will use a single shared reference, with no possibility of error.

The value of the maximum apparent power shall be stated in the “Operating Rule” and then set in CCI.

Figure 3 and Figure 4 show two examples of polygonal curves; the first refers to an installation consisting of generating units and storage systems, while the second refers to an installation consisting of generating units and load.

In this second case, as it can be seen from the polygonal characteristic figure, the maximum active power in absorption is zero, since the power absorbed by the load shall not be taken into account in the polygonal calculation [204].

CCI shall configure the polygonal curve in its internal architecture, so that this information can be made available to DSO or any other enabled operators via the communication interface. The action of entering new and/or changing the characteristic electrical parameters of the installation shall also be stored in the CCI data logger (see O.14).

CCI shall also provide for the updating of the power performance of the plant elements (generating units grouped by primary source, storage systems) to take into account the out of order for maintenance of part of the controlled plant elements. Figure 126 shows an example of a polygonal curve modification for a plant consisting of generating units and storage system, in the event of out-of-order due to failure or maintenance of the storage system.

The updating of power performance shall be carried out using a polygonal curve specific for each plant section (generating units grouped by primary source, storage systems), that shall be updated for any variation not related to the availability of the primary source (thus excluding the update in the event of a variation in solar radiation, reduction in wind strength, etc.).

These updates do not change the previously defined S_{max} value: it is in fact expressed with reference to maximum performance and remains as a reference for all the quantities expressed in per unit.

[203] The maximum apparent power is a mathematical construction defined to be greater than any value of active or reactive power exchanged by the plant with the grid within its capability.

[204] The Standard does not prescribe the use of the load as an active part of the control functions.

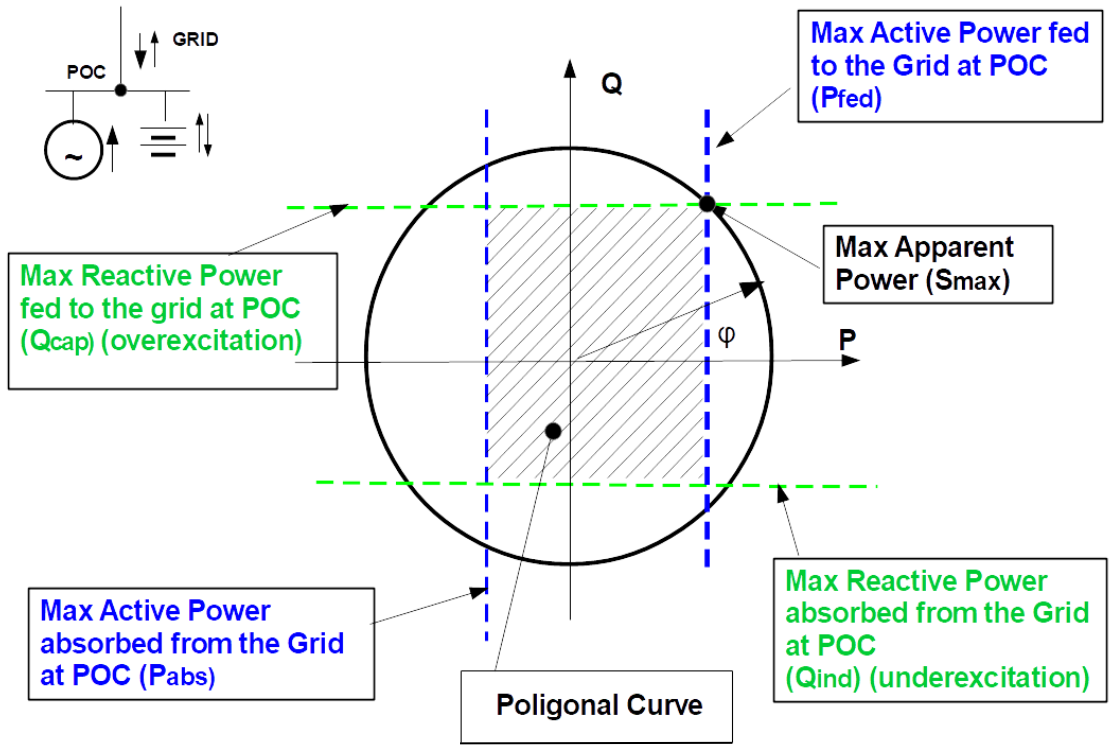

Figure 124 – Example of polygonal characteristic and related electrical quantities for a plant with generating and storage units

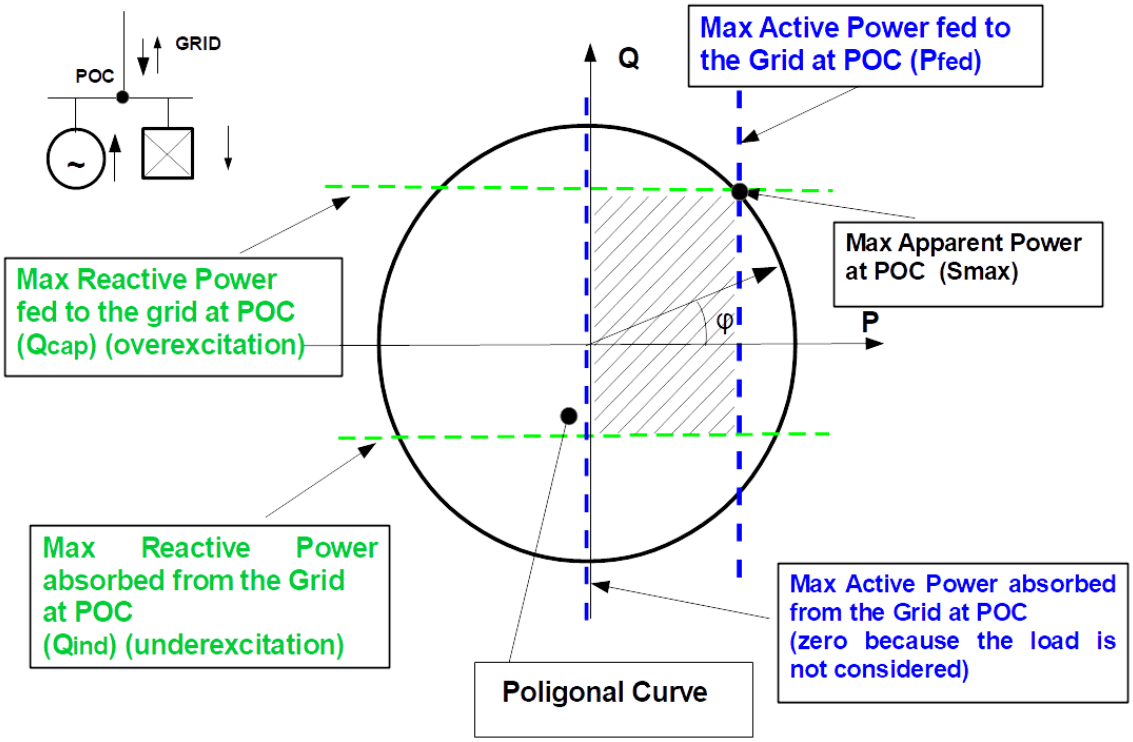

Figure 125 – Example of polygonal characteristic and related electrical quantities for a plant with generating unit and load

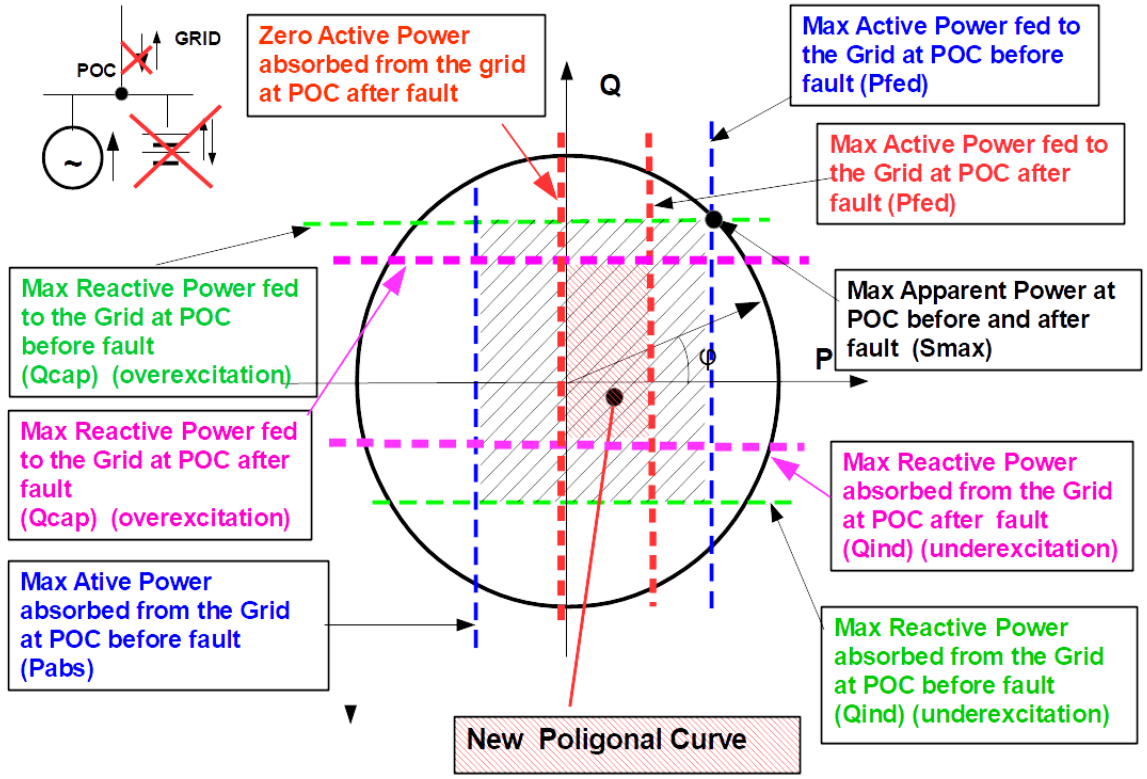

Figure 126 – Example of polygonal features and related electrical quantities for the plant in Figure 3 in case of unavailability of the storage system due to failure

O.8.3 Measurements for estimating the power flows of the MV network of interest to the DSO (PF1)

In addition to the power performance of the plant as mentioned in the previous clause O.8.2, again in accordance with the prescriptions of CEI 0-16, clause 8.10, CCI shall be set up to acquire and transmit towards DSO the main electrical quantities of the installation (P, Q, V) at the point of connection (POC) to allow DSO to monitor both the power flows towards its own grid and the voltage at POC.

The measurements of P, Q and V relating to the POC shall be processed it as defined in IEC 61557-12, according to the accuracy classes defined in O.13.2.1, using the fixed block interval method with a duration of 4 (see Annex B of IEC 61557-12).

The measurements shall be made available immediately after the aggregation period, complete with time stamp and quality index.

The mode of transmission of these measurements shall make the measurement data available at the interface of CCI to DSO with a periodicity of 4s. The expiry of each period shall be synchronous with the instants at 00, 04, 08, ... seconds of each minute.

O.8.4 Measurements for the observability of the MV network of interest to TSO (PF1)

For the purposes of observability of the MV network for the security of the electrical grid, CCI shall be designed to acquire from the plant and transmit to TSO through DSO to which the plant is subordinate [205] the following information, in accordance with Annex A.6 of TSO Grid Code, as established by ARERA Resolution 36/2020/R/EEL:

[205] DSO may also make use of a third-party DSO to perform the service. In the event of explicit and motivated waiver by the competent DSO, including the reasoned impossibility of using a third-party DSO, the data must be sent directly to TSO. In these cases, the Producer shall apply Annex A.13 of the TSO Grid Code.

a) active power (P) and reactive power (Q) measurements related to POC as identified in clause O.8.4;

b) measurements of the total active power (P) produced by the plant, aggregated by primary energy source[206]

c) measurements of the active power (P) produced by each generating unit of defined size and technology, taken at the terminals of the same unit. The following three types of generating units shall be taken into account

   i. inverters[207] of generating units of nominal power P >= 170 kW

   ii. inverters of storage systems of rated power P >= 50 kW

   iii. Rotating generators of rated P power >= 250 kW

The measurements referred to under b) and c) can be achieved:

- by direct acquisition of electrical quantities by CCI;
- by numerical processing from the measurements made available by the individual plant elements;
- as a combination of the two previous techniques.

In performing these functions, CCI acts as a "concentrator" acquiring:

- directly P and Q measurements aggregated or sub-aggregated by source (if the specific design of the plant allows it)
- alternatively the measurements from the individual generating units to be aggregated by source
- the P measurements from the generating units of defined size

and directing them to DSO interface thus making them available for transmission according to IEC 61850, as regulated in Annex T.

The mode of transmission of all these measurements shall make the data available at the interface of CCI to DSO every 04 seconds.

The expiry of each period shall correspond with 00, 04, 08, ... seconds of each minute.

The measurements shall therefore be updated every 4 seconds; each new measurement will overwrite the previous one: no storage at the interface is foreseen.

Measurements taken in this way shall also be complete with time stamp and quality index. The time stamp shall refer to the moment when the measurement is made available at the communication interface towards DSO, thus defining the initial instant of availability.

The accuracy of the measurements, both those taken at the terminals of the generating units and the total plant measurements aggregated by source, shall be in accordance with the requirements of Annex A.6 of the TSO Grid Code (Table 5 and Table 6).

The measurements relating to the individual generating units, according to the types in size and technology defined above, shall be acquired in such a way that they can then be transmitted correlated with the registry of the generating unit from which they originate, as specified in Annex T.

[206] The generation sources to be considered are: wind (any type), photovoltaic, thermoelectric (any type), hydroelectric (any type), storage.

[207] Including wind power that is connected to the grid through inverters.

It is permissible to aggregate measurements acquired from the plant elements at times which are not synchronous with each other, provided that each measurement constituting the aggregate is acquired and aggregated within the 4-second time window immediately preceding the making available of the measurement to the communication interface of CCI.

In order to meet all the above requirements both in terms of measurement accuracy and sampling rate, the architecture of the plant internal communication network must also have adequate performance features.

O.8.5 Measurements for the participation in MSD (PF3)

If the plant want to take part in the market mechanisms (see O.6.2.2), CCI shall be arranged to acquire and transmit to the Aggregator (BSP) the "instantaneous" measurement of the Active Power (P) always at the point of connection (POC).

In this way, CCI constitutes the equipment capable of acquiring and sending in "real time" to the Aggregator the measurements of the total generation power at the connection point, as required by TSO MSD UVAP Regulation approved by ARERA Resolution 583/2017/R/EEL[208] and by the UVAM Regulation[209] approved by ARERA Resolution 482/2018/R/EEL.

CCI shall also have the functional capability to acquire and transmit to the Aggregator the "instantaneous" measurement of Reactive Power (Q).

The measurement of Active Power and Reactive Power matches with the one identified in Subclause O.8.4.

The measurements thus taken shall also now be complete with time stamp and quality index. The time stamp shall refer to the moment in which the measurement is made available at the Aggregator (BSP) communication interface, thus defining the initial instant of availability.

The transmission mode requires that these measurements are then made available every 4s. The expiry of each period must be synchronous with 00, 04, 08, etc. seconds of each minute.

O.8.6 Signals related to plant status (PF1)

Still for the purposes of network observability, CCI, in its monitoring and data exchange function, must acquire and transmit to DSO the following signals:

- status of General Switch (DG, as per CEI 0-16, point 3.22) in accordance with the requirements of CEI 0-16, clause 8.10
- status of Generating Unit Switch (DDG, as per CEI 0-16, point 3.18) or equivalent signal to know the operating status of the individual generating unit, as required by Annex A.6 of the Terna Grid Code

Any change in the status of these elements shall be acquired by CCI and made available to the communication interface for notification within a maximum time of 4 s from the occurrence of the event.

When CCI operates in control mode other status signals shall be acquired in order to know:

- whether the plant as a whole is able to make control functions available,
- whether at least one generating element can be used for control functions,
- whether at least one storage element can be used for the control functions,
- the operational status of each individual control function[210].

[208] Other useful measures for the aggregator to prepare plans for participation in MSD services for the various production units aggregated as UVAP will be better defined at the end of the pilot project testing (UVAP: Productions Enabled Virtual Units).

[209] UVAM = Mixed Enabled Virtual Units (see ARERA Resolution 300/2017/R/eel and s.m.i) including production and load units.

[210] See Appendix A.1 of this Annex for a more detailed discussion of the states assumed by the control modes

The combination of this additional information allows the operational capability of CCI to be known with regard to the possibility of controlling the underlying plant elements[211].

Should CCI provides only monitoring functionality, these status signals must in any case be implemented on the communication interface in order to signal the absence of control functionality.

Should CCI be set up to control user loads, it is suggested that the corresponding status signal also be set up, in anticipation of possible future use.

O.9 Voltage control and active power limitation

O.9.1 Voltage Control (PF2)

The participation in voltage control mode at the point of connection (POC) shall provide for the following control modes of operation:

i. operation in reactive power supply at a fixed and adjustable power factor (cosfi) (as per CEI 0-16, Clause I.2);

ii. operation in reactive power supply with power factor depending on the active power: cosfi = f(P) (as per IEC 0-16, Figure 66, Section I.2);

iii. operation in automatic reactive power supply according to a characteristic curve Q=f(V) (as per IEC 0-16, Figure 67 - Clause I.3);

iv. operation in supply of reactive power on the basis of an external command from DSO (as per CEI 0-16, Clause I.4).

CCI must therefore provide all four control modes listed above.

In the absence of a communication channel with DSO, the control modes i, ii, iii shall be considered as autonomous control functions (based only on measurements at POC), while control mode iv is a slaved control mode.

The four operating modes are mutually exclusive.

The selection of one of the first three can be made by the user locally (on site) or via a remote control terminal; the fourth mode, being a slaved mode, can only be selected via an external DSO command and has priority over the other control modes as indicated in Clause I.4 and as further specified in Subclause O.9.1.4 below.

Basically, no control function is active on CCI ("OFF" condition); different operating conditions are agreed with DSO, at the same time as signing the “Operating Rule”, and enabled, if foreseen, when the CCI is commissioned ("ON" condition).

In case there is the communication service with DSO according to IEC 61850, the control modes i, ii, iii, as well as iv, all become slaved control functions, both for their activation and for the setting of the operating parameters. Activation and deactivation of each of them will be done by external command from DSO, as indicated in Annex T.

CCI must already be provided for this purpose in its architecture.

In case of an interruption of the communication service with DSO[212], CCI shall automatically return to the default operating condition indicated in the “Operating Rule” (i, or ii, or iii, or no function active).

[211] For example, should the communication network between CCI and plant elements it controls be out of service, CCI, while retaining the ability to communicate to the outside world, could not perform any control function

[212] See also clause 0.13.1.2.

Whichever function is enabled and active, CCI must impose the operating condition on the elements it coordinates so that the system as a whole provides the voltage at POC with what is required by the enabled operating mode, respecting the capability curve of each generating and/or storage unit.

If the operating conditions of the plant do not allow the voltage at POC to reach the values set by the active control functions, the plant will go to the closest operating condition, respecting the priorities defined during activation of the control functions (see Clause O.11 below).

O.9.1.1 Operation in reactive power control at a fixed power factor (cosfi)

The control mode for the supply of reactive power with a constant cos(ϕ) value shall fulfil the curve provided for in Clause I.2 of this CEI 0-16.

The cosfi reference is expressed at POC and may be either inductive or capacitive.

In the presence of smart grids on DSO networks, the cosfi value shall be acquired directly from CCI through EN 61850 communication channel.

The manner in which the reactive power required by DSO at POC is distributed among the different plant elements is left to the user and/or plant designer.

If the operating conditions of the plant do not allow the values required by DSO to be reached, the plant will be brought into the operating condition closest to that requested.

O.9.1.2 Operation in reactive power control with power factor depending on the active power

The cosfi=f(P) control mode shall be realised in accordance with the curve in Figure 66 - Clause I.2 of this CEI 0-16 and shall be of parametric type.

The reference of cosfi, P, and V are to be understood as being to POC.

CCI shall allow the values of the voltage lock-in and lock-out thresholds to be set; they shall always be referred to POC.

Verification that the lock-in and lock-out thresholds for voltage have been exceeded shall be carried out on the voltage values averaged over ΔT.

Characteristic curves other than the standard ones may be requested by DSO, as provided for in CEI 016 Clause I.2, and must be set and implemented by CCI.

In such a case as well, in the presence of smart grids on DSO networks, the parameters characterising the curves may be acquired directly by CCI through the EN 61850 communication channel.

With reference to the block diagram in Figure 123, in the operating mode with reactive power supply according to the cosfi=f(P) curve, CCI, through the “slow control ring”, shall calculate the cosfi value (“calculated cosfi”) at a rate of ΔT, as a function of:

- the median value of the measured P compared to the value of the maximum active power supplied (Pfed)
- the regulation curve parameters
- the voltage lock-in and lock-out threshold.

The cosfi value calculated in this way will be compared with the last value transmitted to the “*fast control* ” ring (internal set point) and if the variation between the two values satisfies the relationship:

$$|cosfi_{calculated} - cosfi_{\ internal\ setpoint}| >= \delta cosfi \text{ (where } \delta cosfi = \alpha) \text{ [213]}$$

[213] α must be adjustable: basic α =0.02

it will be transmitted to the “fast control ring” in order to realise the new operating condition required by the control function (see Figure 127).

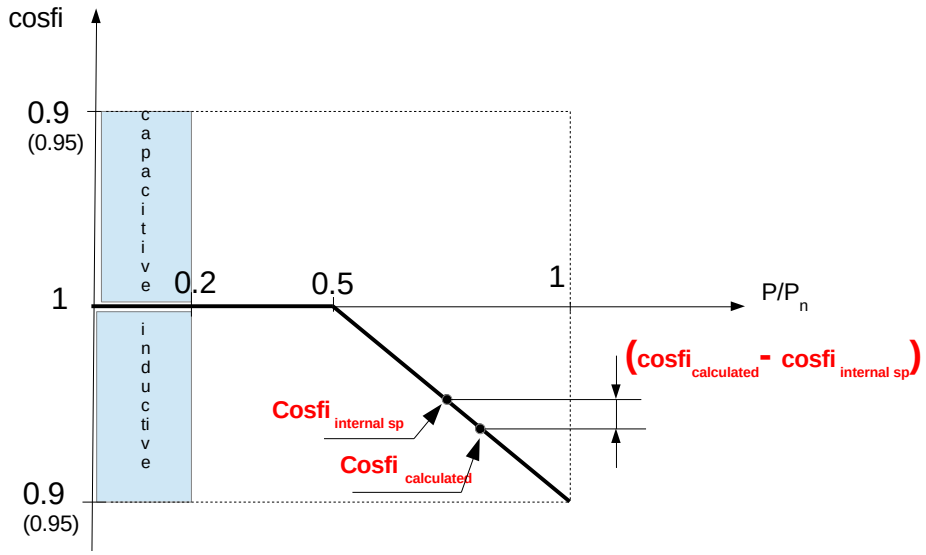

Fig. 127 - Operation with cosfi control depending on the active power [cosfi =f(P)]

O.9.1.3 Operation in automatic reactive power control according to the curve Q=f(V)

The control function Q=f(V) must be realised in accordance with the curves in Figure 67 – Clause I.3 of this CEI 0-16; the curves must be parametric type. The references of Q and V are to be understood as being to POC.

CCI shall make it possible to set:

- the values of the lock-in and lock-out thresholds for active power;
- the values V1i, V2i, V1s, V2s, that characterize the curve respect to the voltage
- the parameter k, variable between -1 and +1.

The verification of the lock-in (0.2 P_{fed}) and lock-out (0.05 P_{fed}) thresholds for active power must be carried out on the values averaged over ΔT. Characteristic curves other than the standard ones may be requested by DSO, as provided for in Clause I.3 of this standard, and shall be set and implemented by CCI.

In this case too, in the presence of smart grids on DSO networks, the parameters characterising the curves may be acquired directly by CCI through EN 61850 communication channel.

With reference to the block diagram in Figure 123, when CCI is in operation at Q=f(V), the CCI, through the "*slow control* ring” shall calculate the value of Q (Qcalculated) at a rate of ΔT as a function of the averaged value of the measured V, the regulation curve parameters and the lock-in and lock-out thresholds if applicable.

The Q value calculated in this way will be compared with the last value transmitted to the “fast control ring” (QInternal Set point) and if the variation between the two values satisfies the relationship:

$$|(Q_{calculated} - Q_{internal\ sp})| >= \delta Q \text{ (where } \delta Q = \sigma) \text{ (214)}$$

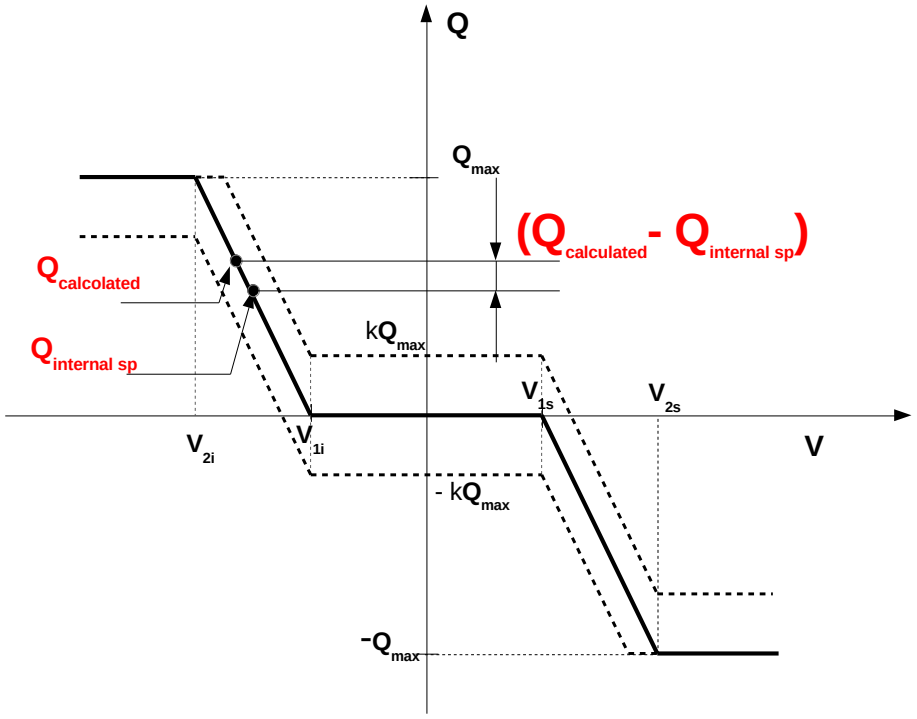

Fig. 128 Operation in automatic reactive power control according to curve Q=f(V)

the internal set-point will be transmitted to the “fast control ring” in order to realise the new operating condition that the Q(V) control function requires (see Figure 128).

(214) **σ** shall be adjustable. Basically, σ = 5%Qmax

O.9.1.4 Operation in Voltage control mode with reactive power fed into the grid on external command from DSO

The control function for the fed of reactive power on external command must comply with the function provided for in Annex I, item 4 of this CEI 0-16.

The reference of Q is to be understood as being to POC, and may be either inductive or capacitive. The function start to operate in the presence of a command transmitted by DSO, conveyed through an IEC 61850 communication channel, which requires the supply of reactive power by the plant. It is therefore a slaved function.

The manner in which the reactive power requested by DSO is distributed among the various plant elements is left to the User and/or plant designer.

Even in this case, if the operating conditions of the plant do not allow the values requested by DSO to be reached, the plant will be brought into the operating condition closest to that requested.

O.9.2 Active Power Limitation (PF2)

The limitation function of the active power fed into the grid at connection point (POC) shall be set up in CCI to cope with the following two, non-exclusive cases:

- limitation for voltage values close to 110% of rated voltage (Un) (Subclause 8.8.6.3.1 of CEI 0-16);
- limitation on external command from the DSO (Subclause 8.8.6.3.4 of CEI 0-16).

In both cases, the limitation, as a basic rule, shall be achieved by means of a reduction of the power fed into the grid by the various generating units of the plant (mode i).

If in the plant is present a storage system, the limitation of the active feed-in power can also be achieved through the absorption of active power by the storage system, if compatible with its state of charge (mode ii). The architecture of CCI shall be designed for this purpose.

Depending on the type of plant (presence of generation units and storage systems) and on how the architecture of CCI is developed, the two technical possibilities (i) and (ii) of limiting the active power fed into the grid can be used alternatively to one another or through an appropriate combination of the two.

The choice between the two possibilities is, in these cases, left to the plant designer or producer: in any case, no active power limitation step larger than those stated for in CEI 0-16 may be envisaged.

O.9.2.1 Limitation of active power supply for voltage values close to 110% of Un

The function is intended to prevent disconnection of the plant from the grid due to overvoltage protection when the voltage values at the POC are close to 110% Un, as specified in clause 8.8.6.3.1 of CEI 0-16 [(215)].

The function is an autonomous function. It must be activated by the User's decision, exclusively through the User's terminal or on site or through remote control terminal.

Both the activation of the limitation function and its intervention shall be signalled and stored in CCI Data logger (see Clause O.14).

To avoid instability between the following two control functions:

- active power limitation for voltage at POC close to 1.1 Un;
- voltage control according to the curve Q=Q(V);

the evaluation and selection of the values V1s, V2s, V1i and V2i of the curve in Figure 67 - Clause I.3 of CEI 0-16 shall be carried out with particular care, in relation to the specific characteristics of the plant and the characteristics of DSO network at POC.

O.9.2.2 Limitation of active power fed to the POC on external command from DSO

This function is activated by a command from DSO for DSO's needs: it is therefore a slaved function.

In the absence of the communication channel with DSO, power reductions or disconnection may still be requested by DSO by means of a predefined procedure laid down in the “Operating Rule” (see Subclause 8.8.6.3.4 of CEI 0-16).

In this case the implementation of such a request shall be carried out by the User either on site or via remote control terminal.

O.9.2.3 Modulation of active power fed to the POC on external command from DSO

This function is designed to be activated by a command from DSO for DSO's needs: it is therefore a slaved function. The "Modulation of Active Power on external Command" function is identical in implementation to function O.10.3.1 "Set-Point Function of Active Power on external Command".

(215) If the overvoltage protection were far away from POC, the voltage at the terminals of individual plant elements could exceed the 110% limit even if at POC this limit was not reached. The control and compliance with the voltage levels for individual system elements is under the responsibility of the user and/or planner, who may decide to use the system controller for this function.

O.9.3 Participation in defence plans

Subclause 8.8.6.5 of the CEI 0-16 prescribes that all generating plant shall participate in the “defence plans” of the SEN (National Electric System) through the partial or total reduction of generated active power to be achieved by means of telecommands sent by a remote control centre.

CCI is able to operate the partial or total reduction of production by means of the active power limitation control, which operates with the dynamics foreseen in O.7.3.3. However, CCI cannot perform the functions of fast disconnection of generating/storage units as required by the CEI 0-16 in Annex M, since, as stated in O.2, CCI shall not interact with the interface protection for protective functions.

Therefore, in order to govern the "participation in defence plans" function, it is still necessary to install the device prescribed in Annex M of CEI 016. This device shall be suitably interfaced with CCI so that it detects the disconnection of plant from the grid and does not take any other conflicting action [(216)]. For this purpose, CCI must be equipped with suitable physical connections.

O.10 Plant operation management and participation in the Dispatching Services Market

CCI can be used, at the discretion of the Producer, to perform the following additional functions:

- specific gradient in power generation at plant start-up
- specific gradient in power generation after reconnection to the grid

as defined in this CEI 0-16, clauses 8.8.4 and 8.8.7.2 respectively.

It may also be set up to perform the functions necessary to:

- participate in the Dispatching Services Market;
- meet specific needs of the producer, such as, for example, optimised plant management.

O.10.1 Power output gradient at the start up (PF3)

This functionality can be realised either on individual units or within CCI. The choice is left to the Producer

The centralised start up power growth operation realised in CCI shall take place with a positive gradient of power not exceeding 20%Pn/min, in compliance with the requirements of this CEI 0-16, clause 8.8.4 (Start-up, synchronisation and power output gradient). In order to realise this specific function, CCI may operate by starting up the various generating units according to an appropriate time sequence or by imposing the appropriate gradient on each unit, in any case granting the growth of total power supply at POC within the limits indicated above.

O.10.2 Power output gradient during reconnection (PF3)

In the event of system re-entry following a trip of the interface protection, the power growth shall occur in the same way as in the case of the plant start-up. CCI, if equipped with the function, shall only enable the re-connection of the plant when the grid conditions in terms of voltage and frequency meet the conditions of clause 8.8.7.2 of CEI 016 (Conditions for re-connection after the interface protection trip.

(216) In general, plant disconnection from the grid, even when carried out by protective devices, shall be monitored by CCI so that it can act in the most appropriate manner with respect to the operating conditions of the plant

O.10.3 Participation in the Dispatching Services Market (PF3)

In order for the plant to participate in the provision of services for MSD, the CCI must implement the following functionalities:

- a function able to receive an external command for the Active Power Set-Point, with the features outlined in clause O.10.3.1;
- the measurements of the Active Power at POC for the plant monitoring with the features outlined in clause O.8.5;
- the logical services for communication(217) (direct or indirect) of the commands and measurements defined above.

CCI shall also have the functional capability to receive and implement the command of Reactive Power set-point (see the following Subclause O.10.3.2) as well as the functional capability to acquire and transmit the "instantaneous" Reactive Power (Q) measurement, as already provided for in clause O.8.5.

For the participation in MSD services, the regulation and control functionalities shall be present and active according to the principles set out in clause from O.7.2 onwards.

O.10.3.1 Active Power Set-Point Function on External Command

The "Active Power Set-Point" function, once activated following an external command forces the plant to feed the required active power value(218) to POC , taking into account the technical limits of the capability of its elements. The function can only be activated, respecting the priority among the different control functions, when the communication channel is present: it is therefore a slaved function.

Basically, the function acts through the regulation of the power generated by the various generating units in the plant, in order to obtain the total active power output required to POC.

If the plant is equipped with a storage system, the control of the active power to be fed in the grid can also be achieved through the modulation of the active power by the storage system, if compatible with its state of charge. The architecture of CCI may also be designed for this purpose.

In any case, CCI shall bring the active power to the POC to the required value within the time prescribed in O.7.3.1.

It should be noted that the Set-Point value of the active power has a sign (sign "-" for the Active Power in feed-in; sign "+" for the Active Power in absorption) and that the updating of its value shall take place within the minimum updating times prescribed in O.7.3.3.

O.10.3.2 Reactive Power Set-point Function on External Command

This function is designed to be activated by an external command from the Aggregator for its own needs. The "Reactive Power Set-Point Function on external command " is identical in implementation to function O.9.1.4 "Operation in voltage control mode with reactive power output on external command from DSO".

(217) This Annex does not currently regulate the way in which communications are transported for MSD participation services. The need to specify a CCI that "does not have to be replaced every time the Aggregator changes, thereby protecting producers and favouring competition" (see ARERA "DOCUMENT FOR CONSULTATION 298/2016/R/EEL), could lead to a different orientation.

(218) The function is different from the mandatory active power limitation function, the latter intended to define the maximum value of power fed into POC that shall not be exceeded, leaving the plant installation free to feed in lower power values.

O.10.4 Optimised Management of the Plant (PF3)

CCI may also provide for the management of all plant elements in its architecture, with a view of optimising the management of energy resources or in accordance with other criteria selected by the user and/or designer of the plant.

Optimised plant management could involve not only the management of the generating units, but also the possible management of the internal load.

In any case, these aspects are not within the scope of this Annex; the development of this function is left to the decision of the user and/or system designer.

O.11 Compatibility and priority among the control functions of CCI

Some of the control modes can potentially be activated simultaneously, provided they are functionally compatible with each other:

- Functions acting on active power are functionally compatible with functions acting on reactive power;
- Functions acting on reactive power are mutually incompatible;
- Functions acting on the active power set-point ("Modulation of active power fed to DSO", Active Power Set-Point Function on external command from the DSO) are mutually incompatible;
- The functions acting on the active power limitation can be active at the same time as the others; in fact, the functions intended to limit the active power ("Active power limitation for V≈110%Vn" and "Limitation of the active power fed to POC on external command from the DSO") only become effective when they execute the limiting action. The resulting active power value is determined by considering the order of executive priority of the control functions(219).

The executive priority between the control functions is regulated in Table 1, (regardless of whether the function was activated in a slaved or autonomous manner).

(219) For example:

- if the Set-Point P function is active and its value is set at 50% S_{max} and the Limit P function is active and its value is set at 70% S_{max}, CCI will act to obtain at POC the active power value equal to P=50% S_{max} (if compatible with the availability of the primary source).
- if, on the other hand, the Set-Point P function is active and its value is set at 80% S_{max} and the Limit P function is active and its value is always set at 70% S_{max}, CCI will act to obtain an active power value of P=70% Smax S_{max} at POC (if compatible with the availability of the primary source).

Table 1 – Priority between control modes

Control functions	Priority index
Active power limit intervention for V≈110%VN (O.9.2.1)	1
Active power limitation on external DSO control (O.9.2.2)	2
Modulation of active power to POC on external command from DSO (O.9.2.3)	3
Active Power Set-Point function on external command (O.10.3.1)	4
Operation in voltage regulation with reactive power supply on external command from DSO (O.9.1.4)	5
Set point Power factor (Set-point Cosφ) O.9.1.1)	6
Reactive Power control Q=f(V) (O.9.1.3)	6
Reactive Power control Cosφ=f(P) (O.9.1.2)	6
Reactive Power Set-Point function on external command (O.10.3.2)	7

Priority numeric index represents the activation priority among several functions. The lower the index, the higher the priority. If the activation of a function is requested while another non-compatible function is already active, CCI must regulate the situation by adopting the following behaviour;

- if the new function has higher or equal executive priority (i.e. lower or equal numeric index) to the function already active, the new function is activated with simultaneous deactivation of the previous function;
- if the new function has a lower priority (higher numeric index) than the already active function, the new function is not activated.

If the activation of a function is requested while another compatible function is already active and the simultaneous fulfilment of these two requests is impossible due to the technical limits of the installation, CCI must regulate this situation by applying the provisions of clause 8.8.6. For example, if a photovoltaic plant (FV) is operating at maximum active power and receives a command related to reactive power exchange, the plant shall reduce the active power fed in so as to meet the reactive power exchange request.

If an electrical quantity is not subject to the action of any control function, it is brought to the nominal operating conditions defined for the specific plant.

The functions of limiting active power in the presence of over-frequency transients and/or increasing active power in the presence of under-frequency transients originating on the grid (see Subclauses 8.8.6.3.2 and 8.8.6.3.3 of CEI 0-16) which are implemented at the level of the individual machine have priority over any other control function, whether autonomous or slaved. Therefore, if the afore mentioned function becomes operative the controller of each generating unit must give priority to frequency control.

The disconnection of total or part of the plant from the grid following a remote telecommand in the contest of the participation in the defence plans has a similar priority.

The setting of priorities must be provided with variable logic, in order to allow the order of priorities to be changed should it become necessary to change it, for reasons dictated either by network problems or by developments in market services.

Any change in settings must be recorded in the data logger.

O.12 Schematic Diagram of CCI installation

The following figures show some simplified diagrams of possible installation solutions of CCI: they are to be considered only as examples to facilitate the understanding of this Annex.

The diagram in Figure 129 refers to the case in which General Switch (DG) and Interface Switch (DDI) coincide; Figure 130 refers instead to the case in which DG and DDI are separate and positioned in different points of the plant.

Finally, Figure 131 refers to a typical photovoltaic plant configuration with several generating units fed through a single transformer. Each generating unit has its own DDI.

-

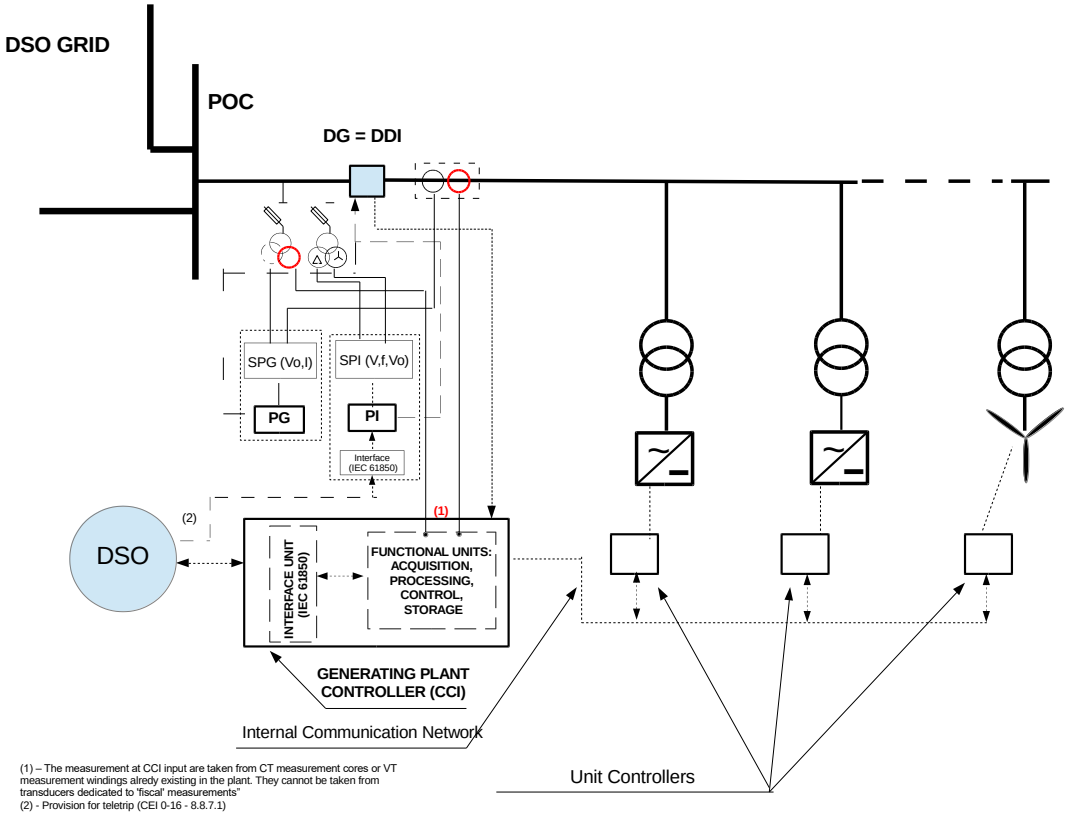

Fig. 129 - Simplified diagram of the plant solution in the case: DG=DDI

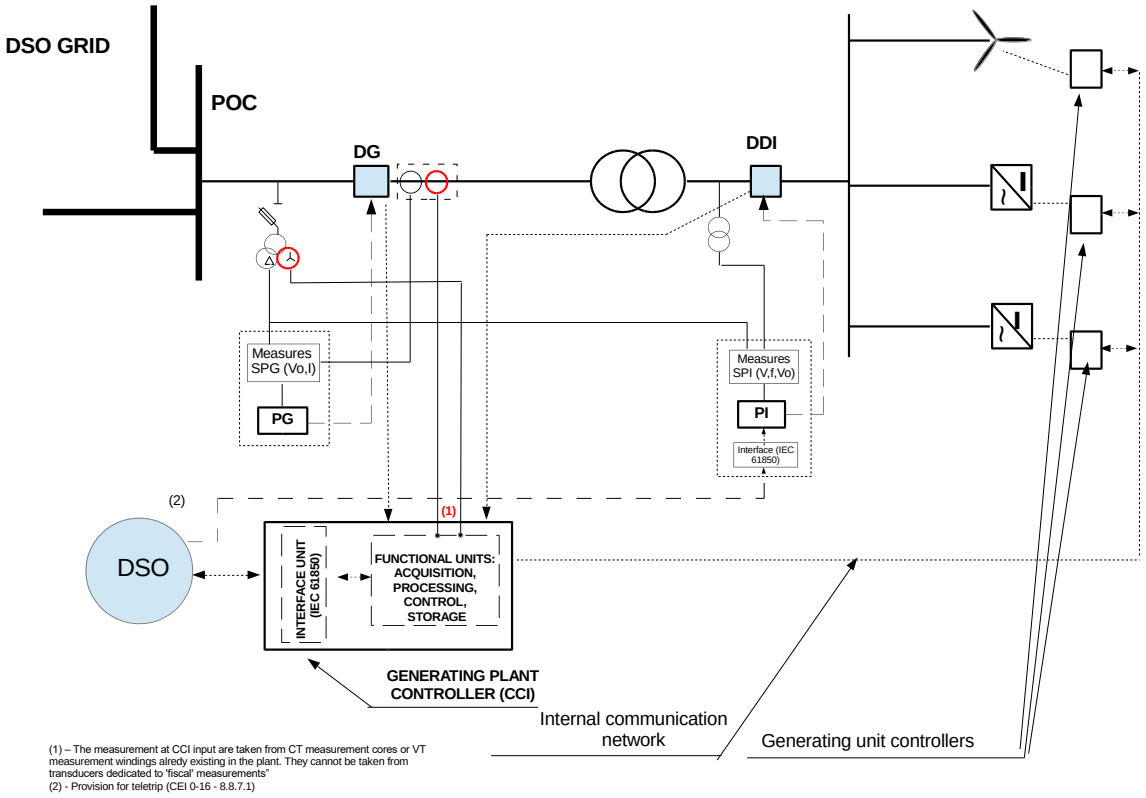

Fig. 130 Simplified diagram of the plant solution in the case: DG≠DDI

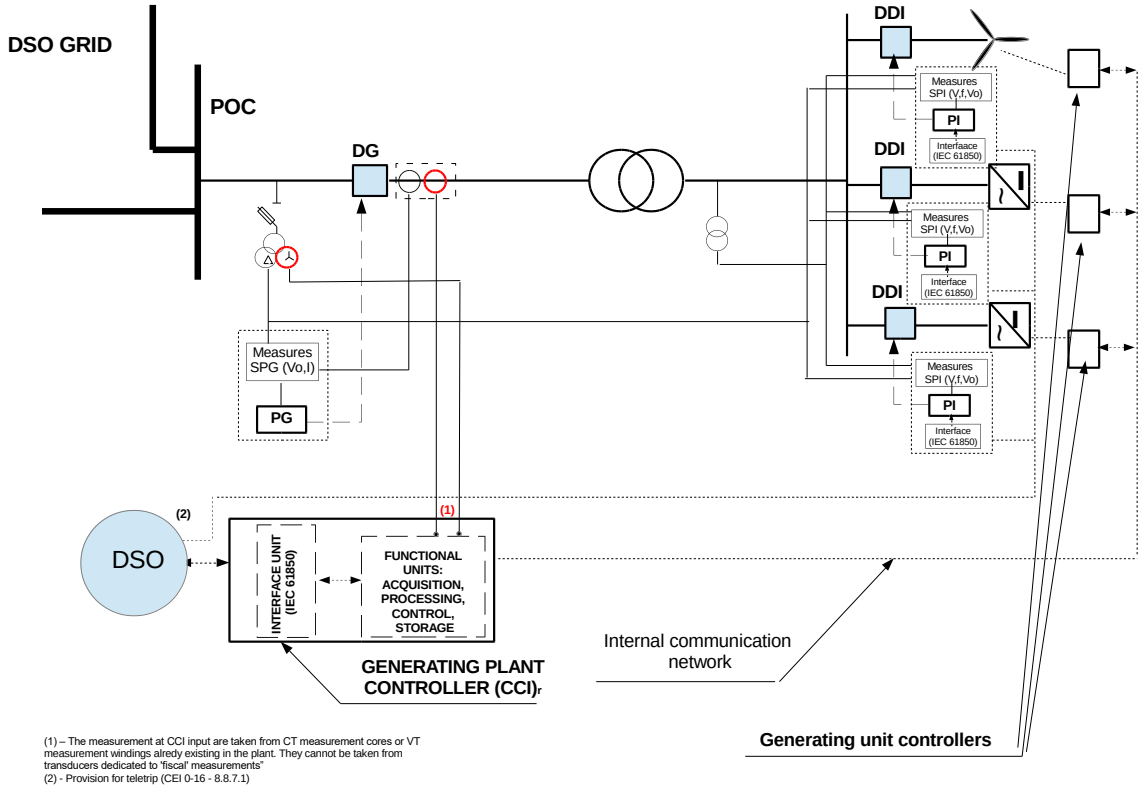

Fig. 131 Simplified plant solution diagram for a generation installation with several generating units and several DDI fed through transformer

O.13 CCI main technical features

CCI is required to be an industrial apparatus that respects the characteristics of robustness, insulation, environmental compatibility, electromagnetic compatibility, as well as any other requirements of best design practice in relation to the environment in which the device is installed and the way in which it is to operate.

O.13.1 Interfaces

CCI shall have separate network interfaces for communication services between CCI, DSO and any external operators enabled to remote commands. Communication with internal plant elements shall be arranged on separate interfaces(220).

All security aspects (cybersecurity) must be ensured according to the indications given in Annex T of this CEI 0-16.

Integration modes of CCI into the architecture of the communication network is not in the scope of this Annex. See however the content of footnote(197).

Data exchange between the interfaces of CCI shall be excluded, i.e. no internal services of CCI shall allow data exchange between the communication interfaces. CCI shall not implement switch or bridge functions with respect to data exchange passing over its interfaces and must be designed to ensure compliance with this condition.

(220) The possible use of networking devices (routers, switches, etc.) due to installation complexity and/or the need for communication with external operators shall be appropriately integrated with CCI without degrading the performance of CCI.

O.13.1.1 Interfaces physical features

CCI shall have:

- two separate network interfaces towards the outside of the plant (see O.13.2.1);
- one interface for configuration and maintenance services (see O.13.1.2);
- additional interfaces as required for connection to plant elements

whose characterisation is given in the following paragraphs.

O.13.1.1.1 Network interfaces towards the outside

For the management of external communications, CCI shall provide two separate network interfaces, of the Ethernet type conforming to IEEE 802.3-2015, in order to clearly distinguish the services associated with them.

The network interfaces shall be distinguished as follows:

Eth_A) Communication towards DSO

Eth_B) Communication to other external operators enabled to remote commands[221]

The Eth_A interface shall be 100BaseFX type, implemented with optical type technology with dual LC connector for 1310 nm multimode fibre.

The Eth B interface shall be basically 10BaseT / 100BaseTX auto negotiation, auto MDI/MDIX type[222].

The network interfaces shall also support communication services based on:

- TCP/IPv4 (mandatory) and possibly IPv6 (facultative) protocols
- IEC 61850 family protocols (MMS, GOOSE)
- SSL client and server (with TLS 1.2 and higher support according IEC 62351-4, -8 and -9)
- DHCP and DNS Forwarding functionality

The status of these two network interfaces (status of the physical link and of the data link) shall be made available in the data logger (see clause O.15). The check of the data link shall make it possible to detect the presence or absence of the logical communication service.

For both interfaces, access to the logical services must meet the security criteria (cyber security) defined in Annex T.

O.13.1.1.2 Interface for local CCI Configuration and Maintenance Services

This interface is dedicated to initial configuration or maintenance of CCI in case of its recovery

This interface can be realised with serial technology or USB port.

IP communication technology is excluded for security reasons.

Technologies for recognising users requesting access to the CCI must be implemented on this port in order to ensure effective protection against unauthorised access.

[221] Remote User and/or Aggregator

[222] The port can be prepared as a small form-factor pluggable transceiver module (SFP).

O.13.1.2 Logical communication services with the DSO

The Eth_A interface with DSO shall allow the exchange of information (measurements, signals and commands) through a logical communication channel according to EN 61850, in accordance with what required in Annex T and summarised in Appendix A (Exchange of information and commands between DSO and CCI) of this Annex O.

These interchange signals shall interact only with CCI: no direct interaction with the equipment and switches/protective devices of the plant shall be foreseen.

The availability of the communication channel makes all control functions suitable for slave operation. The parameters characterising the control functions as well as their activation/deactivation status shall be acquired directly from CCI, again through EN 61850 communication channel.

The update of any data foreseen in the data model described in Annex T, regardless of the cause that led to the modification of the data, shall be made promptly available to the logical communication services with DSO and with other operators enabled for remote connection.

If CCI performs control functions and the loss of communication channel with DSO occurs, CCI must automatically switch to a pre-configured operating mode (autonomous control mode). The switch to this autonomous mode should occur no earlier than a predefined time, sufficient to ensure that the loss of communication is permanent. When communication is restored, CCI shall return to DSO request.

The pre-configured mode of operation as well as the waiting time for switching to this mode shall be agreed with DSO and stated in the “Operating rule”[223].

The cybersecurity requirements for these services in Annex T shall also be taken into account.

O.13.1.3 Logical Communication Services with External Operators enabled to Remote Connection

The Eth_B interface is dedicated to the logical communication services with further external operators enabled for remote connection.

This Annex does not regulate the modality of data exchange through this interface, with the exception of the requirements in clause O.13.2.1 and in the rest of this Annex, insofar as they apply to this type of services.

However, Annex T shall be taken into account with regard to cybersecurity requirements for these services, applicable to protocols standardised by international bodies or organisations, such as IEC, ITU-T, IETF.

The update of any data foreseen in the data model described in Annex T, regardless of the cause that led to the modification of the data, must be made promptly available to the logical communication service with DSO and with the external operator actors enabled for remote connection.

If the functionalities for participation in the Dispatching Services Market are activated (see Subclause O.10.4), the logical services for communication with the Aggregator (BSP) are basically associated with the same Eth_B interface[224].

If communication with the Aggregator is lost, the CCI must automatically switch to a pre-configured operating mode. The switch to this autonomous regulation mode shall take place no earlier than a predefined time, sufficient to ensure that the loss of communication is permanent. When communication is restored, CCI must make the logical communication services with the Aggregator available again.

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[223] DSO, by means of the “Operating Rules”, establishes which functions shall be configured to activate in autonomous mode in the event of loss of communication. These functions will be activated according to the priority rules already defined in O.11 and will remain active until communication is restored.

[224] The model currently considered in Annex T excludes multiple Aggregators simultaneously interfaced to the same generating plant or unit.

The pre-configured operation mode as well as the waiting time for switching to this mode are agreed with the Aggregator, after verification with DSO[225].

O.13.1.4 Interface of CCI with plant elements

The interface towards the plant elements coordinated by CCI shall allow the exchange of information with them via one (or more) internal communication networks (hardwired, serial, Ethernet), which carry information via industrial protocols (modbus RTU, modbus TCP, 61850, etc.) suitable in terms of their characteristics to ensure the required performance.

The choice of the type and architecture of the communication networks within the plant is left to the user, depending on the functional performance to which the CCI must respond[226].

Under no circumstances may the network interfaces Eth_A and Eth_B be used.

The communication between CCI and the plant elements shall be constantly monitored by CCI.

O.13.1.5 Interface of plant elements with the CCI

In order to be monitored and coordinated by CCI, the plant elements shall provide an interface to allow the exchange of information between the installation elements and CCI.

The communication between the plant elements and CCI shall be constantly monitored by the elements themselves.

When CCI is operational and the communication channel is active, the plant elements coordinated by CCI shall operate in a mode of operation subjected to CCI (Slaved to CCI)[227].

On the contrary, the plant elements shall operate according to the control functions provided in this CEI 0-16 for each element.

In this way, although the function of regulating the quantities at the point of connection according to the control logic governed by CCI is lacking, it is possible, thanks to the logics implemented on the individual elements, to use the network support capabilities integrated in the elements themselves, as provided for in this CEI 0-16.

O.13.2 Measurement inputs

CCI shall be equipped, either directly or by means of appropriate transduction, acquisition and measurement devices, with an adequate number of inputs able of receiving signals for the measurements of V, P, Q at the POC as required in clause O.8.4, as well as the measurements required in O.8.5 and, if applicable, in O.8.6. In all cases the requirements in terms of measurement accuracy, update frequency and type of measurements shall be complied with.

O.13.2.1 Requirements for transducers and measuring converters

The following performances are required:

- Accuracy class for the measuring converter <= 0.2;
- Accuracy class for current (CT) and voltage (VT): <= 0.5;
- Rated burden (where applicable): 5 or 10 VA.

[225] The aggregator establishes, in agreement with the owner of the plant and DSO, which functions shall be configured to be activated in autonomous mode in the event of loss of communication. These functions will be activated respecting the priority rules already defined in O.10 and will remain active until the restore of communication.

[226] For example, if the installation shall take part in the Dispatching Services Market (Set-Point Function of the Active Power on external command) the internal communication network must present performance characteristics, consistent with the required services and the necessary timeframe.

[227] In any case, the safety of the plant shall be preserved; consequently, the producer must be guaranteed to operate the plant in accordance with the relevant safety and correct operation constraints.

Measurements may also be taken using non-conventional transducers provide that they are in compliance with the requirements of this standard and with the accuracy class indicated above.

If measuring transducers common to other services, such as plant measurement or protection, are used, it shall be ensured that there is no interference between their respective uses, if necessary by adopting dedicated windings or cores. The use of dedicated CTs and VT for fiscal measurements is excluded.

For the measurements of total P produced by the plant aggregated by the energy source and for the measurements of P produced by the generating units indicated in Subclause O.8.4, item c), where dedicated CTs, VTs and Measurement Converters are required, they shall have the same characteristics indicated for measurements at POC.

With these performance, the accuracy requirements of the tables 5 and 6 of the Annex A.6 of the TSO Grid Code are fulfilled. Different performances are acceptable as long as the accuracy of the measurements to be made available at the interface of CCI with DSO are congruent with the requirements of that Annex.

O.13.3 CCI Power supply

Circuits of CCI and associated data communication equipment shall be supplied by an auxiliary voltage source: its availability shall be guaranteed by a UPS or battery back-up for at least one hour[228].

O.13.4 Firmware/software updating

CCI shall provide for updating its firmware/software through an appropriate procedure in order to correct errors and/or vulnerabilities in the firmware/software.

The firmware/software update activity could lead to disruptions in the functionality of CCI (e.g. interruption of monitoring and control functions), as well as cause malfunctions (e.g. abnormal behaviour or failure to restart the CCI).

CCI must therefore shall be designed to allow its firmware/software updating only in accordance with a specific procedure that:

i. disables the functionality of CCI in a controlled manner,

ii. certifies the full integrity and originality of the new firmware/software through a verification procedure of its digital signature, based on the equipment manufacturer's certificate

iii. checks, using the authentication methods described in Annex T, the credentials and authorisations of the User activating the upgrade procedure.

The procedure[229] shall be activated only by the User, after informing DSO (and any other authorised external operators).Modalities and timescales for this information will be agreed with DSO and set out in the “Operating Rule.”

The firmware/software update activity shall be recorded in the CCI data logger. No step in the procedure must delete the data in the aforementioned data logger.

Further cybersecurity requirements that shall be fulfilled are covered in Annex T.

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[228] In case the functions of CCI are integrated in one of the apparatus of the plant ,that requirement concerns the section of the apparatus responsible for providing CCI functionality.

[229] In order to ensure a secure update process, the procedure defined by the user, in coordination with the equipment manufacturer, should provide for:

- protect the upgrade process through an authentication procedure of the entities involved based on a public key infrastructure;
- appropriately protect the backup images at rest on dedicated repositories accessible only after authentication;
- protect the image transport process through an appropriate encrypted channel;
- protect the authentication credentials of the user activating the update procedure, through a secure area of the device, allowing them to be changed.

O.13.5 Internal clock and synchronisation

CCI shall be equipped with a GPS receiver in order to acquire and maintain synchronised time.

The time will be expressed with reference to UTC (Coordinated Universal Time) Greenwich Mean Time[230]. The uncertainty of the time reference shall not exceed +/- 100 ms.

In the momentary loss of external synchronism or in case of disconnection of power supply, the internal clock of CCI shall maintain the time with a maximum allowable drift of 1s/day over the entire range of allowable operating temperatures.

If the GPS receiver is not directly integrated into CCI, the communication protocol for time synchronisation and related cybersecurity aspects that shall be complied with are addressed in Annex T.

O.13.6 Self-diagnostics

CCI shall include the necessary self-diagnostic functions to detect and report any malfunctions inside the CCI or that can be located in the interface with the systems with which it interconnects, and that may compromise the normal performance of the functions for which CCI is intended.

In the event of anomalies on the interfaces (including the lack of communication), the self-diagnostic function shall provide a control procedure which, once the anomaly has been detected, deactivates the slaved operating mode and/or any control functions that may be active and activates the autonomous control functions, using the parameters specifically defined for them at the configuration phase

If an anomaly is self-diagnosed in the hardware or software of CCI such that the control function does not operate under the specified conditions, the functionality of CCI must be automatically deactivated, so that the plant elements controlled by it can switch to operating in their autonomous mode.

In the event of anomalies relating to the monitoring functionality, the quality indications associated with the measurements must be appropriately enhanced.

In the event of intervention of the self-diagnostic function resulting in CCI being out of service, an appropriate alarm signal must be provided to be recorded in the data logger complete with any available diagnostic indications (see Clause O.14).

O.13.7 Hardware Cybersecurity

CCI shall not expose any active physical test ports.

CCI shall also be protected against possible tampering with appropriate solutions such as:

- Circuits that invalidate NVRAM when the enclosure is opened;
- Sensors that blow safety fuses when light is detected;
- Sensors that trigger a warning when the position of the device is changed;
- Epoxy covering of core circuit components;
- Warnings generated when internal components are removed from the CCI.

O.13.7.1 Bootloader

Interactive boot functionality offered by the bootloader shall be disabled and the ability to change bootloader configurations shall be precluded.

[230] In accordance with the requirements of the TSO Grid Code, Annex A.13, Subclause 6.1.3.4.

If a bootloader lockout password is used, this protection shall not be easily bypassed In addition, the Bootloader shall be stored on a secure partition that shall neither be overwritten during a firmware update nor accessed/changed from the firmware partition itself.

O.13.7.2 Asset Inventory

CCI shall be arranged to be interfaced to an Asset Inventory infrastructure as indicated in Annex T of this Standard.

In addition, it shall be configured to make available an up-to-date list of fields useful for its unique identification, through the support of dedicated Application Programming Interfaces (API).

O.13.10 Reliability

The reliability requirements, understood as availability ("Availability"), expressed in the TSO Grid Code, Annex A.13, Article 6.2, which must be complied with by the subject who is responsible for the installation and maintenance of the CCI equipment and of its connection to the DSO, a subject that will be defined as a result of the procedure initiated by ARERA Resolution 628/18/R/EEL.

O.14 Data logger

A function for storing events (data logger) shall be provided, with the purpose of allowing verification of the correct availability of CCI and its operating status.

The correct functioning of the CCI shall be checked by verifying:

- presence of CCI power supply;
- presence/absence of communication to DSO;
- presence/absence of communication towards external operators (status of physical link and data link);
- presence/absence of communication towards the plant elements coordinated by CCI (status of physical link and data link);
- functionality of CCI;
- functionality of measurement devices;

The result of the verification must be recorded in the CCI data logger.

The following information shall also be stored:

- status (open/closed) of the General Switch (DG);
- status (open/closed) of the Interface Switch (es) (DI);
- power on/off (and cause) of CCI; firmware update (including version) and failed firmware updates;
- Connections and/or disconnections to the communication network at irregular intervals;
- Connection to abnormal service endpoints or connection to service endpoints at inappropriate times;
- A significantly different fingerprint of network traffic than normal (e.g. such as port scanning, deep scanning, etc.);
- Poorly formed messages and errors in verifying message authenticity;
- Failed authentication attempts;
- Successful authentications;
- Change of system time;

- Unsuccessful attempts to modify keys or credentials;
- Changes to keys or credentials;
- Reset of alarm or error logs.

If a bootloader lockout password (according to O.13.7.1) is used, the following further events shall be stored:

- Failed boot authentication attempts:
- Successful boot authentication.

In addition, the following additional information shall be stored for the purpose of enabling the verification of further functionality distinct from monitoring:

- start/stop/activation status of the control functions(231);
- events that caused the issuing of commands from CCI to the plant elements coordinated by it (such as exceeding the 110% Vn threshold, intervention of a control function, implementation of a set-point, etc.);
- commands from DSO, with relevant parameters;
- commands from any other authorised external operator, with relevant parameters;
- tripping of the General Protection (PG);
- tripping of the Interface Protection (PI);
- tripping of the function implementing the defence plan (Teletripping as Annex M)
- tripping of the overfrequency (and underfrequency) regulation by the controlled machines/units.

The storage of the above-mentioned events complete with date and time (yyyy/mm/dd hh:mm:ss) shall extend for not less than 2048 events and shall take place on an internal holder that cannot be overwritten by the User; it shall be possible to read and export the data to the memory by means of an interface made available by CCI manufacturer (e.g. software supplied with CCI).

Access to the data logger shall be protected with the usual procedures (username/password, etc.).

With regard to the logics for the diagnostics of the Amperometric/Volmeter circuits, please refer to what has already been established for the data logger associated with the PG in points C.3.2.9 and C.3.2.10 of CEI 016

CCI shall allow the User to remotely read the log files using a standard protocol (for example, using a SIEM -Security Information Event Management System via syslog protocol, according to RFC 5424).

O.15 Tests

The tests to be performed on CCI in order to verify its conformity to Annex O are:

- functional tests (O.15.1);
- general conformity tests (O.15.2);
- cybersecurity related tests (O.15.3).

(231) See Appendix O.1 for a description of the operational states of the control functions.

Where CCI is implemented as an integrated functionality in other plant elements (e.g. integrated as an additional functionality in the inverter controller of a generating unit acting as Master for the other units or integrated functionality in a protection device) the functional tests and the cybersecurity tests shall be carried out keeping the functionalities of both devices enabled (CCI own functionalities and integrating device functionalities); the functional tests shall cover CCI own functionalities while ensuring the lack of interference with respect to the functionalities foreseen for the integrating device and vice versa

O.15.1 Functional tests

The purpose of the functional tests described in this Subclause is to verify the capability of CCI alone to operate in accordance with the prescribed requirements based on the functionalities to be performed by CCI[232] (see clause O.6).Measurement accuracy according to the accuracy class of the measurement converter, immunity to disturbance quantities and compliance with update intervals shall be verified.

The correct communication of CCI according to IEC 61850 shall be verified, in accordance with what stated in Annex T, both for signals and measurements transmission and for reception and implementation of commands.

The self-diagnostic functionality according to clause O.13.6 shall be checked, verifying that the procedures provided for both in case of loss of communication and in case of operational degradation of CCI are correctly performed.

The data logging functionality as provided in O.14 shall also be verified, as well as any other functionality prescribed in this Annex based on the functionality to be performed by CCI.

For regulation and control performance, both in autonomous and slaved mode, it shall be verified, for each functionality of CCI, that by modifying the parameters of specific input signals to CCI characterising the individual functions to be verified, command consistent with the required function are presented at the outputs.

It shall also be verified that when each set function lapses, CCI re-activates the default pre-configured control function and presents output signals consistent with it.

Finally, it shall be verified that in the event of communication channel loss, CCI re-activates the pre-configured function after the predefined time-out.

O.15.2 General conformity tests

The general conformity tests are the ones referred to in CEI EN 61557-12[233]. They shall verify the requirements in the manner specified therein.

The reference temperature class shall not be lower than K55, as defined in CEI EN 61557-12. PMD-A qualification is not required.

For CCI integrated in other devices, evaluating that safety issues are pre-eminent in the host device (which is expected to have more exposed surfaces, its own inputs and outputs, etc.), it is necessary that the integration of CCI take place within the reference framework of the standards of the integrating device, while respecting the requirements of CEI EN 61557-12 as far as applicable and using the most stringent levels in case of overlapping.

[232] Annex O provides mandatory functions (PF1), optional functions (PF2) and discretionary functions (PF3): CCI shall be verified with respect to the functions that the specific equipment is called upon to perform. In particular, it shall always be verified against the mandatory functions as required at the date of publication of this edition of Annex O by ARERA Resolution 36/2020/R/EEL.

[233] CEI EN 61557-12 recalls, among others, IEC 61010-1 and the applicable parts of the same series, among which, considering the role of CCI as controller, it is considered appropriate to point out the IEC 61010-2-201.

O.15.3 Hardware Cybersecurity Testing

With respect to cybersecurity hardware aspects of CCI, at least level 3 tamper resistance shall be certified through industry standard certifications (*Federal Information Processing Standards - FIPS 140-2 "Security Requirements for Cryptographic Modules*") obtained from independent entities.

O.15.4 Apparatus Compliance

CCI shall be CE marked.

Compliance with the requirements listed in the preceding paragraphs shall be attested by a "Declaration of Conformity" of the equipment. Such Declaration shall be issued by and under the responsibility of the Manufacturer, in the form of a self-certification by the same Manufacturer, drawn up in accordance with Article 47 of "*Presidential Decree no. 445 of 28 December 2000 (DPR)"*, and shall be made available by the User to the DSO at the time of connection of the Plant to the grid.

The documentation certifying the passing of the tests (test reports) shall be kept by the Manufacturer for at least 20 years from the last production. The same documentation shall in any case be made available to the DSO by the Manufacturer on its website.

In the case of integrated devices, the test report shall contain details of all tests and test levels applied referring to the device as a whole.

The "Declaration of Conformity" of the equipment shall contain all the information necessary for the identification of the device.

The execution of the required environmental compatibility tests (insulation, climatic and EMC tests) shall take place in a laboratory accredited according to CEI UNI EN ISO/IEC 17025 by a body belonging to the European cooperation for Accreditation (EA) (in Italy the accrediting body is ACCREDIA).

Functional tests may alternatively take place:

a) in the above-mentioned laboratory, or

b) in the manufacturer's laboratories, or external non-accredited laboratories.

In case b) the tests shall be carried out under the supervision and responsibility of an appropriate certifying body that meets the requirements of UNI CEI EN ISO/IEC 17065 or, alternatively, under the supervision and responsibility of the accredited laboratory at which the EMC tests were carried out.

In addition, a certification shall be provided that the production of the apparatus is carried out under a quality regime according to ISO 9001, ed. 2000 [as amended and supplemented]). This certification must also be issued by and under the responsibility of the Manufacturer and shall be delivered, upon request, by the User to the DSO at the time of the connection of the plant to the grid.

Certifications of compliance with the IEC 61850 series standards shall be issued by a laboratory accredited by the UCA User Group.

The conformity tests of the secure transport profile defined by the IEC 62351-3 standard are described in the Technical Specification IEC 62351-100-3 *"Conformance test cases for IEC 62351-3, the secure communication extension for profiles including TCP/IP"*. The relevant certificate of conformity must be issued by an accredited certification body.

For CCI product security, “ISA Secure Embedded Device Security Assurance[234] (EDSA) v3.0.0” certification is required for compliance with IEC 62443-4-1 “Security for industrial automation and control systems - Part 4-1: Secure product development lifecycle requirements” and IEC 62443-4-2 “Security for industrial automation and control systems - Part 4-2: Technical security requirements for IACS components - Part 4-2: Technical security requirements for IACS components”.

Test certificates, certifications and declarations of conformity shall be specific for the different CCI functionalities and shall be available according to the priority determined by ARERA Resolution 36/2020/R/EEL (mandatory functions first).

O.15.5 Commissioning tests

The purpose of these tests is to verify:

- that CCI assembly, internal plant communication network, controllers and measuring devices of the individual generating units are correctly configured;
- that the interface between CCI and DSO is configured to ensure both the information exchange to DSO and the reception of controls from DSO (interoperability).

The commissioning test plan related to interoperability shall be agreed with the relevant DSO and planned in relation to the functionalities active on CCI according to the priorities established by ARERA (mandatory functionalities primary).

In the event that the firmware upgrade process procedure was not able to protect the certificate-based entities, such tests and/or other functional tests that may be necessary to verify the correct operability of CCI shall be performed.

[234] In the new version v3.0.0, the EDSA certification process has four levels of assurance, according to which the following analyses shall be performed on the CCI device and its development process:

- Assessment of the development process:
  - Evaluation of the safety development process that is an essential component for the analysis of compliance with IEC 62443-4-1;
  - Evaluation of the outputs of the safety development process functional to the device;
- Device evaluation:
  - functional safety evaluation, that is an essential component for compliance analysis to IEC 62443-4-2;
  - Device robustness analysis, consisting of a robustness analysis of the communication protocols.

APPENDIX O-1
(informative)

Information exchange between DSO and CCI

App. O-1.1 General

Information exchange with DSO according to EN 61850 is regulated in Annex T.

In order to explain how to associate the information required in Annex T with the data available to CCI, some examples are given here.

The exchange of information may take place on demand, or on a periodic basis.

The information messages are conceptually grouped according to the information content carried in the categories shown in Annex T, Table 1, reproduced in the following table.

Table App.O-1 - 1: Organisation of messages to be exchanged

Messages relating to the plant features	Information from the plant concerning configuration, characteristics and rated capacities. This information is derived from the plant and is not subject to modification by remote processes.
	This is the data in the corresponding section of Annex T to be filled in based on information essentially obtainable from the Operating Rule. The information is divided into three macrogroups: General Characteristics of the plant; Characteristics of the set of Generating units; Characteristics of the set of Storage units. These are data to be entered at the same time with the writing of the Operating Rule and being related to the characteristics of the plant they should be updated only when there are changes in plant elements that alter its overall characteristics. They are also the data that allow DSO to calculate the quantities related to the whole plant and construct the corresponding polygonal curve. Concerning the section "Available Control Functions" present in the macrogroup "General Installation Characteristics," it should be noted that for new installations, the listed control functions are all available on CCI in both expected modes (Autonomous, Slaved) according to the requirement of this Standard. They should therefore be stated in the Table with the acronym: "Both." If CCI is to be used on existing plant that do not allow a specific function to be activated or that do not allow it to be used as Autonomous or Slaved mode, this information should be declared using the appropriate acronym (NA=Not Available; Auton= autonomous only; Slaved =slaved only).

Messages on the plant 's operational status	Information concerning the operational status of the plant and of elements in the installation itself, such as switch positions. The status may change as a result of events in the plant or as a result of remote commands.
	This is data that allows DSO to know in real time the operating condition of the plant (in service or out of service, in control mode and which) both as a whole and in the elements grouped by categories. These data shall be updated whenever there is a change in the plant operating conditions. They are therefore “dynamic” not “static” information. They are information relating to logical status. The correspondence between “operating mode” and the acronyms used in Annex T is as follows: At Rest (Inactive) =OFF; Active=ON; Operational=ACT. For a better understanding of the use of these acronyms, please refer to Figure 132 Appendix O-1
Messages related to plant measurements	Analogue values measured directly or achieved by processing measured quantities such as voltage, current, power, etc.
	These are the measurements of the main electrical quantities (P, Q, V) of the plant at the point of connection (POC), and the measurements of active power (P) and reactive power (Q) of the various generation units divided and aggregated according to primary energy generation source (solar, wind, storage, other sources, etc.).
Messages on operating parameter values	Reference values required for the operation of the functions and algorithms. The parameters are set during the configuration of the CCI and can subsequently be changed remotely.
	This is information on the parameters characterising the various control functions. It is essentially static information (the parameters characterising the functions are entered at the same time with the writing of the “Operating Rule” and, unless changes are requested by DSO, are no longer modified). The activation/deactivation commands of the control functions requested by DSO are conveyed in this group of messages

App. O-1.2. Application example

Refer to the reactive power control function according to the curve Q=Q(V).

Figure 122 shows the case of a plant in which the DSO, due to the voltage rise at the POC, requests the activation of the control function Q=Q(V).

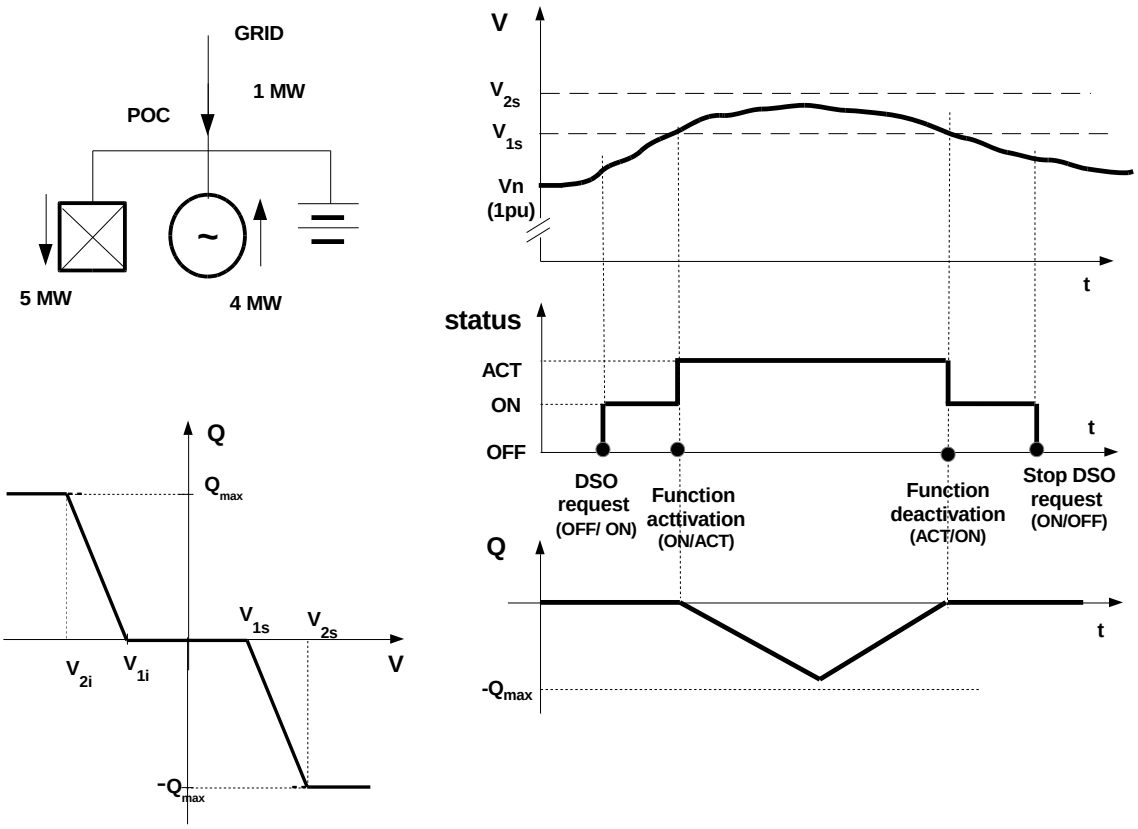

Figure 132 - Simplified example illustrating the information to be transmitted via the EN 61850 communication channel concerning the change of state of the control function Q=Q (V) using the acronyms used in Annex T

The function switches at the time of DSO request from the OFF state to the ON state: if the conditions of active P above the lock-in threshold are verified and the voltage continues to rise until it exceeds the value V1s, the function is activated (switching from the ON state to the ACT state) in order to increase the reactive power absorption from the plant according to the preset curve Q=f(V).

The reactive power absorption continues to grow as long as the voltage remains above V1s (until it reaches its maximum capacity (-Qmax) if the voltage reaches V2s).

When the voltage begins to fall, the reactive power absorption decreases according to the curve Q=Q(V) and then stops decreasing when the voltage falls below V1s (a condition that determines the change of state from ACT to ON).

When the voltage settles below V1s and the DSO deems the control action no longer necessary, the function state changes from ON to OFF.

From the graphs in the Figure it is easy to identify the dynamic information of the plant's operating parameters which shall be acquired by CCI according to Annex T, modified according to the actual operating conditions, and made available to DSO on the EN 61850 communication channel.

App. O-1.3. Summary of functions

We summarise for convenience the control functions, mode of operation and which operator is who can govern the status and parameters of the functions.

App. O-1.3.1 Case a: No communication channel between CCI, DSO and/or possible Aggregator

Control function	Activation
Active power limitation when V≈110%VN	Autonomous, by user
Active power limitation on external DSO command	Autonomous, by user on DSO indication through the ”Operation Rule”
Modulation of active power fed to the POC on external command from DSO	Not allowed
Set-Point active power on external command	Not allowed
Operation in voltage control with reactive power supply on external command from DSO	Autonomous, by user on DSO indication through the ”Operation Rule”
Set point Power Factor Control (Set-point Cosφ)	Autonomous, by user on DSO indication through the ”Operation Rule”
Q=f(V) Control	Autonomous, by user on DSO indication through the ”Operation Rule”
Cosφ =f(P) Control	Autonomous, by user on DSO indication through the ”Operation Rule”
Reactive Power Set-Point control on external command	Not allowed

App. O-1.3.2 Case b: Presence of communication channel between CCI, DSO and /or possible Aggregator

Control function	Activation
Active power limit when V≈110%VN	Autonomous, by user
Active power limitation on external DSO command	Slaved, with remote DSO action
Modulation of active power fed to the POC on external command from DSO	Slaved, with remote DSO action
Set-Point active power on external command	Slaved, with remote Aggregator action(235)
Operation in voltage control with reactive power supply on external command from DSO	Slaved, with remote DSO action
Set point Power factor Control (Set-point Cosφ)	Slaved, with remote DSO action
Q =f(V) Control	Slaved, with remote DSO action
Cosφ=f(P) Control	Slaved, with remote DSO action
Reactive Power Set-Point control on external command	Slaved, with remote Aggregator action(236)

(235) Functionality of an experimental nature.

(236) Functionality set up for possible future use.

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