Marshalls Energy Company

Grid Connection Code for Renewable Power Plants and Battery Storage Plants

Version 0.2

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Version control

Marshalls Energy Company		
Document #	Title: **Grid Connection Code for Renewable Power Plants including Battery Storage Plants**	Print Date: **[Date]**
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1 Objectives

(1) The primary objective of this grid connection code is to specify minimum technical and design grid connection requirements for *Renewable Power Plants* connected to or seeking connection to the Marshalls Energy Company's network.

(2) This document shall be used together with other applicable requirements for connecting to the network.

(3) This code was based on EU Commission Regulation 2016/1388, Kingdom of Swaziland Grid Code for Renewable Power Plants Connected to the Electricity Transmission System or the Distribution System and IEEE 1547, and adapted for the Majuro network

2 Scope

(1) The grid connection requirements in this code shall apply to all *Renewable Power Plants,* which shall for this code include *Battery Storage Plants,* connected or seeking connection to the Marshalls Energy Company's network.

(2) This grid connection code shall, at the minimum, apply to the following technologies:

(a) *Photovoltaic*

(b) *Wind*

(c) *Battery Storage*

(3) Unless otherwise stated, the requirements in this grid connection code shall apply equally to all *Renewable Power Plants*, *Storage Plants* and Types.

(4) The *Renewable Power Plant* shall, for the duration of its generation licence issued by an appropriate authority (MEC to advise who this is), comply with the provisions of this grid connection code and all other applicable codes, rules and regulations.

(5) Where there has been a replacement of or a major modification to an existing *plant*, the *plant owners/operators* shall be required to demonstrate compliance with these requirements before being allowed to operate commercially.

(6) Compliance with this grid connection code shall be applicable to the *Renewable Power Plants* depending on their rated power and, where indicated, the nominal voltage at the *point of connection to the grid*. Accordingly, *Renewable Power Plants* are grouped into the following three Types:

(a) Type A: 0 *MVA* – less than 0.2 *MVA* connected 400 V network

(b) Type B: 0.2 *MVA* – less than 1 *MVA* connected to the 11 kV network or 400 V network

(c) Type C: *1 MVA* or higher and any plants connected to 22 kV network or higher

(7) The requirements of this grid connection code are organized according to above-defined Types.

(8) The *Marshalls Energy Company* shall supply the *Renewable Power Plants* owner with detail of their Network that is sufficient to allow an accurate analysis of the interaction between the plant and the Marshalls Energy Company's network, including information about other generation facilities.

3 Definitions and Abbreviations

Active Power Curtailment Set-point

The limit set by the *Marshalls Energy Company* for the amount of active power that the *Renewable Power Plant* is permitted to generate. This instruction may be issued manually or automatically via a communication facility. The manner of applying the limitation shall be agreed between the parties.

Available Active Power

The amount of active power (MW), measured at the *point of connection to the grid,* that the *Renewable Power Plant* could produce based on plant availability as well as current renewable primary energy conditions (e.g. wind speed, solar radiation or charge available).

Curtailed Active Power

The amount of Active Power that the *Renewable Power Plant* is permitted to generate by the *Marshalls Energy Company* subject to network or system constraints.

Marshalls Energy Company

Means the Marshalls Energy Company established under the Marshalls Islands Act of 1996.

Rated power

The highest active power measured at the *point of connection,* which the *Renewable Power Plant* is designed to continuously supply.

Rated wind speed

The average wind speed at which a *Wind Power Plant* achieves its *rated power*. The average wind speed is calculated as the average value of wind speeds measured at hub height over a period of 10 minutes.

Renewable Power Plant

One or more *unit(s)* and associated equipment, with a stated *rated power,* which has been connected to the same *point of connection* and operating as a single power plant.

It is, therefore, the entire *Renewable Power Plant* that shall be designed to achieve requirements of this code at the *point of connection*. A *Renewable Power Plant* has only one *point of connection*.

In this *code*, the term *Renewable Power Plant* is used as the umbrella term for *a unit* or a system of generating *units* producing electricity based on a primary renewable energy source (e.g. wind, sun, water etc.) and *Battery Storage Plant*. A *Renewable Power Plant* can use different kinds of primary energy source. If a *Renewable Power Plant* consists of a homogeneous type of generating *units* it can be named as follows:

PV Power Plant (*PVPP*)

Single *Photovoltaic* panel or a group of several *Photovoltaic* panels with associated equipment operating as a power plant.

Wind Power Plant (*WPP*)

Single turbine or a group of several turbines driven by wind as fuel with associated equipment operating as a power plant. This is also referred to as a wind energy facility (WEF)

Battery Storage Power Plant (*BSPP*)

Single battery or a group of several batteries installed for system security through provision of frequency and voltage control services and or used for storage of electrical energy.

Renewable Power Plant (*RPP*) Controller

A set of control functions that make it possible to control the *Renewable Power Plant* at the *point of connection to the grid*. The set of control functions shall form a part of the *Renewable Power Plant.*

***RPP* Generator**

Means a legal entity that is licensed to develop and operate a *Renewable Power Plant*.

Voltage Ride Through (*VRT*) Capability

The capability of the *Renewable Power Plant* to stay connected to the network and keep operating following voltage dips or surges caused by short-circuits or disturbances on any or all phases in the *Network*.

4 Tolerance of Frequency and Voltage Deviations

(1) The *Renewable Power Plant* shall be able to withstand frequency and voltage deviations at the point of connection to the grid under normal and abnormal operating conditions described in this grid connection code while reducing the active power as little as possible.

(2) The *Renewable Power Plant* shall be able to support network frequency and voltage stability in line with the requirements of this grid connection code.

(3) Normal operating conditions and abnormal operating conditions are described in section 4.1 and section 4.2, respectively.

4.1 *Normal Operating Conditions*

(1) Unless otherwise stated, requirements in this section shall apply to all Types of *Renewable Power Plants*.

(2) All *Renewable Power Plants* shall be designed to be capable of operating within the voltage range of ±10% around the nominal voltage at the point of connection to the grid. The actual operating voltage differs from location to location, and this shall be decided by the *Marshalls Energy Company* in consultation with the affected customers (including the *Renewable Power Plant*), and implemented by the *Renewable Power Plant owner or operator*.

(3) The nominal frequency of the *Marshalls Energy Company*'s network is 60 Hz and is normally controlled within the limits of 59.5 to 60.5 Hz.

(4) All *Renewable Power Plants* facilities shall be capable of remaining connected to the network and operate within the frequency range of 57.0 to 62.0 Hz.

(5) *Marshalls Energy Company* and the power-generating facility owner may agree on wider frequency ranges, longer minimum times for operation or specific requirements for combined frequency and voltage deviations to ensure the best use of the technical capabilities of a power-generating facility, if it is required to preserve or to restore system security.

(6) Tripping times for when frequency goes outside of the normal operating range of 59.0 to 61.0 Hz shall be agreed with *Marshalls Energy Company*. *Marshalls Energy Company* shall co-ordinate such settings to minimise the risk of cascade tripping and network collapse.

(7) All *Renewable Power Plants* shall be capable of continuous operation, at up to 100% active power output, within a frequency range of 59.0 to 61.0 Hz and voltage range of 10% either side of nominal voltage.

(8) The active power output from all Type B and C *Renewable Power Plants* shall not decrease by more than a proportionate decrease when the frequency varies within the range of 57.0 to 59.0 Hz.

(9) When the frequency on the *Marshalls Energy Company*'s network is higher than 62.0 Hz for longer than 4 seconds, the *Renewable Power Plant* may be disconnected from the grid.

(10) When the frequency on the *Marshalls Energy Company*'s network is less than 57.0 Hz for longer than 200ms, the *Renewable Power Plant* may be disconnected.

(11) The *Renewable Power Plant* shall remain connected to the *Marshalls Energy Company*'s network for a rate of change of frequency of up to and including 1.0 Hz per second measured over a rolling window of 500 ms, provided that the network frequency remains within the range of 57.0 to 59.0 Hz.

4.1.1 Synchronising to the *Marshalls Energy Company's* network

(1) *Renewable Power Plants* of Type B and C shall only be allowed to connect to the *Marshalls Energy Company*'s network, at the earliest, 3 seconds after:

(a) for Type B, the voltage at the *point of connection to the grid* is within ±10% around the nominal voltage,

(b) for Type C, the voltage at the *point of connection to the grid* is within ±5% around the nominal voltage,

(c) frequency in the *Marshalls Energy Company*'s network is within the range of 59.0 Hz and 60.2 Hz.

(d) removal of the synchronisation block signal received from the *Marshalls Energy Company's SCADA* system

4.2 *Abnormal Operating Conditions*

4.2.1 Tolerance to sudden voltage drops and peaks

(1) *Renewable Power Plants* of Types B and C shall be designed to withstand and fulfil, at the *point of connection to the grid*, voltage conditions described in this section and illustrated in Figure 1 below.

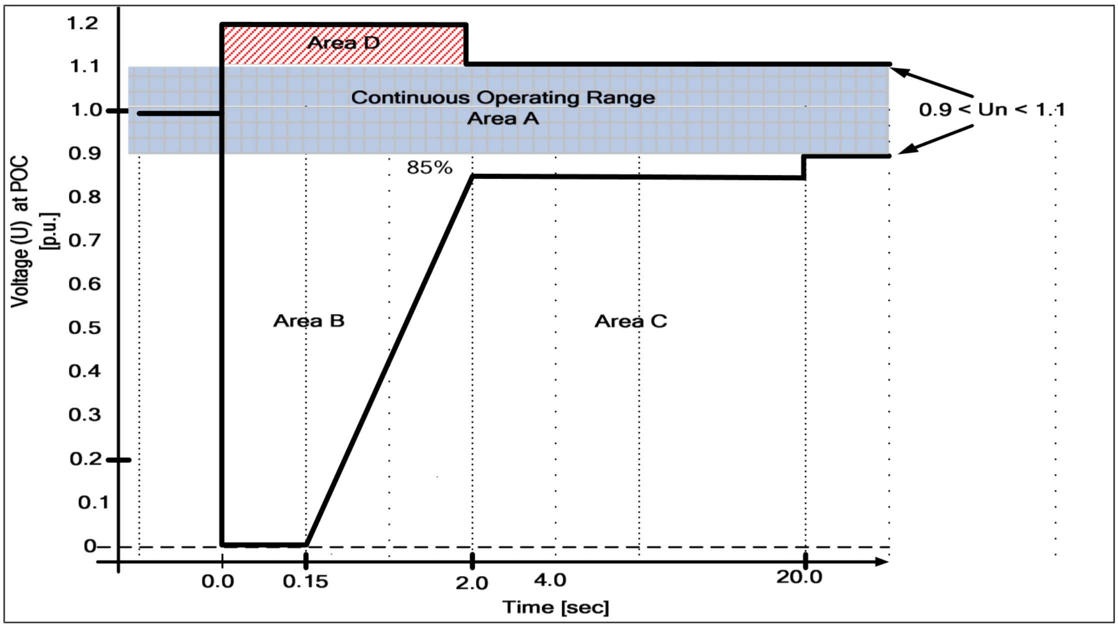
(2) The *Renewable Power Plant* shall be designed to withstand voltage drops and peaks, as illustrated in Figure 1 and supply or absorb reactive current within the transient design ratings of the plant.

(3) The *Renewable Power Plant* shall be able to withstand voltage drops to zero, measured at the *point of connection to the grid*, for a minimum period of 0.150 seconds without disconnecting, as shown in Figure 1.

(4) The *Renewable Power Plant* shall be able to withstand voltage peaks up to 120% of the nominal voltage, measured at the *point of connection to the grid*, for a minimum period of 2 seconds without disconnecting, as shown in Figure 1.

(5) Figure 1 shall apply to all types of faults (symmetrical and asymmetrical i.e. one-, two- or three-phase faults) and the bold line shall represent the minimum voltage of all the phases.

Figure 1: Voltage Ride Through Capability for the Renewable Power Plant of Type B and C



If the voltage (U) reverts to area A during a fault sequence, subsequent voltage drops shall be regarded as a new fault condition. If several successive fault sequences occur within area B and evolve into area C, disconnection is allowed, see Figure 1.

(6) In connection with symmetrical fault sequences in areas B and D of Figure 1, the *Renewable Power Plant* shall have the capability of controlling the reactive power. The following requirements shall be complied with:

(a) **Area A:** The *Renewable Power Plant* shall stay connected to the network and maintain normal production.

(b) **Area B:** The *Renewable Power Plant* shall stay connected to the network. In addition, the *Renewable Power Plant* shall provide maximum voltage support by supplying a controlled amount of reactive current so as to ensure that the *Renewable Power Plant* helps to stabilise the voltage.

(c) **Area C (Figure 1):** Disconnecting the *Renewable Power Plant* is allowed.

(d) **Area D:** The *Renewable Power Plant* shall stay connected to the network and provide maximum voltage support by absorbing a controlled amount of reactive current so as to ensure that the *Renewable Power Plant* helps to stabilise the voltage within the design capability offered by the *Renewable Power Plant*.

(7) The supply of reactive power has first priority in area B, while the supply of active power has second priority. If possible, active power shall be maintained during voltage drops, but a reduction in active power within the *Renewable Power Plant's* design specifications is acceptable.

5 Frequency Response

(1) In case of frequency deviations in the *Marshalls Energy Company*'s network, the *Renewable Power Plants* shall be designed to be capable to provide power-frequency response in order to stabilise the grid *frequency*. The metering accuracy for the grid frequency shall be at least ±10mHz.

5.1 Power-frequency response curve for *Renewable Power Plants*

(1) This subsection applies to all *Renewable Power Plants.*

(2) *Renewable Power Plants* shall be designed to be capable to provide power-frequency response as illustrated in Figure 2.

(3) The default settings for f_{min}, f_{max}, f_1 to f_5 shall be as shown in Table 1 for *Renewable Power Plants* unless otherwise agreed with *Marshalls Energy Company*.

(4) It shall be possible to set the frequency response control function for all frequency points shown in Figure 2. It shall be possible to set the frequencies f_{min}, f_{max}, as well as f_1 to f_5 to any value in the range of 57 - 62 Hz with a minimum accuracy of 10 mHz.

(5) The *Renewable Power Plants* shall be equipped with the frequency control *droop* settings as illustrated in Figure 2. Each *droop* setting shall be adjustable between 0% and 10%. The actual *droop* setting shall be as agreed with the *Marshalls Energy Company*.

(6) The *Marshalls Energy Company* shall decide and advise the *Renewable Power Plants* on the *droop* settings required to perform the control between the various frequency points.

(7) If the active power from the *Renewable Power Plants* is regulated downward below the unit's design limit P_{min}, shutting-down of individual *Renewable Power Plant units* is allowed.

(8) It shall be possible to activate and deactivate the frequency response control function in the interval from f_{min} to f_{max}.

(9) If the frequency control setpoint (P_{Delta}) is to be changed, such change shall be commenced and be completed no later than 1 second after receipt of an order to change the setpoint.

(10) The accuracy of the control performed (i.e. change in active power output) and of the setpoint shall not deviate by more than ±2% of the setpoint value or by ±0.5% of the rated power, depending on which yields the highest tolerance.

Figure 2: Frequency response requirement for *Renewable Power Plants*

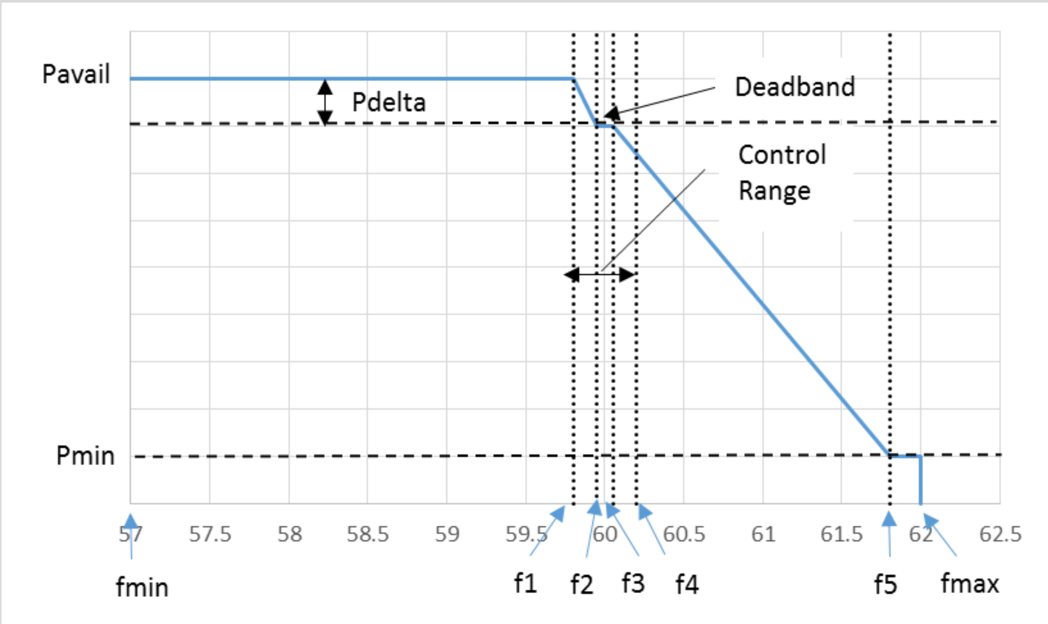


Table 1: Frequency Default Settings

Type	Type A PVPP & WPP	Type B & C PVPP & WPP	Type A, B & C BSPP	Unit
f_{min}	57.0	57.0	57.0	Hz
f_{max}	62.0	62.0	62.0	Hz
f_1	57.0	59.0	59.8	Hz
f_2	57.0	59.5	59.9	Hz
f_3	60.5	60.5	60.1	Hz
f_4	61.0	61.0	60.2	Hz
f_5	62.0	62.0	62.0	Hz
P_{Delta}	0	As agreed with *CPUC*	100	%

5.2 Procedure for setting and changing the power-frequency response curves for Renewable Power Plants

(1) The *Marshalls Energy Company* shall give the Renewable Power Plants owner/operator a minimum of 2 weeks if changes to any of the frequency response parameters (i.e. f_1 to f_5) are required. The *Renewable Power Plant* owner/operator shall confirm with the *Marshalls Energy Company* that requested changes have been implemented within two weeks of receiving the *Marshalls Energy Company's* request.

5.3 Synthetic Inertia

(1) Type B & C asynchronous *Renewable Power Plants* shall be capable of providing synthetic inertia in response to frequency changes, activated in low and/or high frequency conditions by rapidly adjusting the active power injected to or withdrawn from the AC network in order to limit the rate of change of frequency. The requirement shall at least take account of the results of the studies undertaken by *MEC* to identify if there is a need to set out minimum inertia.

(2) The principle of the control system to provide Synthetic Inertia and the associated performance parameters shall be agreed between *MEC* and the *Renewable Power Plant* owner.

6 <u>Reactive Power Capabilities</u>

6.1 Type A *Renewable Power Plants*

(1) Type A *Renewable Power Plants* shall not actively regulate the voltage at the *point of connection*. Type A *Renewable Power Plants* shall not cause the network voltage the *point of connection* to exceed the normal operating voltage limits specified in Paragraph 4.1.

6.2 Type B & C *Renewable Power Plants*

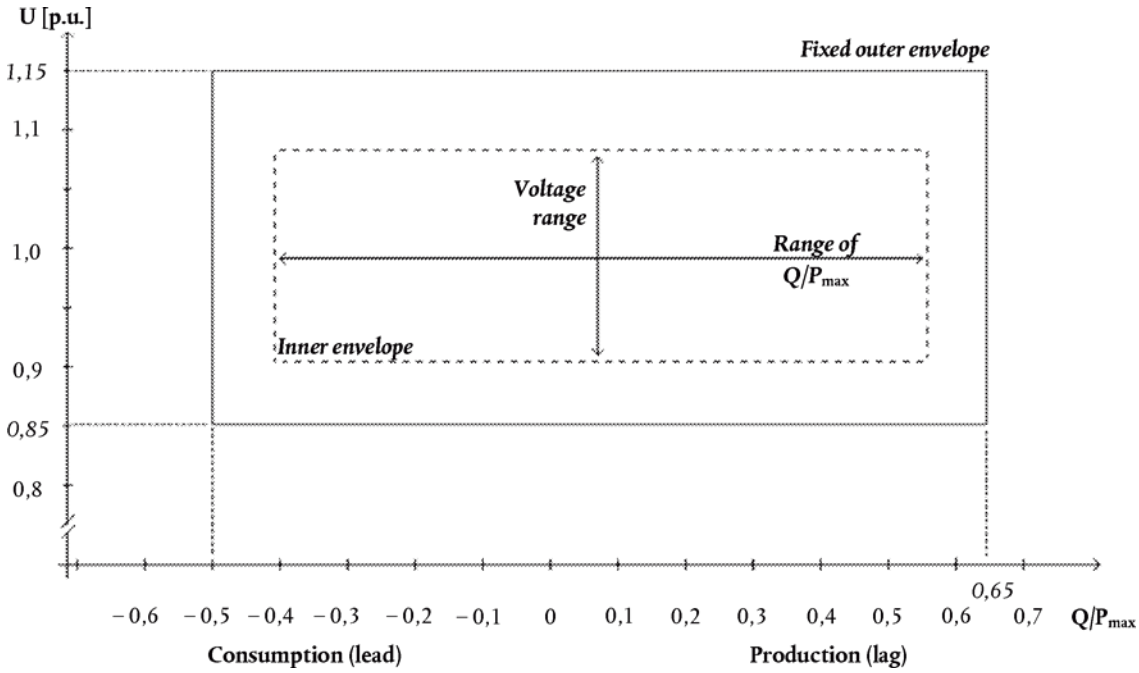
(1) *Type B* & C *Renewable Power Plants* shall be designed with the capability to operate in a voltage (V), power factor or reactive power (Q or *MVA*r) control modes as described in section 7 below. The actual operating mode (V, power factor or Q control) as well as the operating point shall be agreed with the *Marshalls Energy Company*.

(2) The reactive power capabilities of *Type B* & C *Renewable Power Plants* at maximum active power transmission capacity shall be capable of providing reactive power at its maximum active power transmission capacity and at every possible operating point below maximum active power transmission capacity. For *Type B* & C *BSPP* the minimum power shall be the full import capability of the *BSPP* when charging.

(3) *Renewable Power Plants* shall be designed to supply rated power (MW) for power factors as specified in Table 2 below.

(4) In addition the *Renewable Power Plants* shall be designed in such a way that the operating point can lie anywhere within the inner envelope in Figure 3.

Figure 3 U-Q/P$_{max}$-profile of *Renewable Power Plants*



The diagram represents the boundaries of the U-Q/P$_{max}$-profile with the voltage at the connection point, expressed in pu, against the ratio of the reactive power (Q) to the maximum capacity (P$_{max}$). The position, size and shape of the inner envelope are indicative.

Table 2 Parameters for the inner envelope for Type B & C

Type	Maximum range of Q/P$_{max}$	Maximum range of steady- state voltage level in PU
Type B	0.975	0.225
Type C	0.95	0.225

7 Reactive Power and Voltage Control Functions

(1) The following requirements shall apply to *Type B & C Renewable Power Plants*.

(2) The Renewable Power Plants shall be equipped with reactive power control functions capable of controlling the reactive power supplied by the Renewable Power Plants at the point of connection to the grid as well as a voltage control function capable of controlling the voltage at the point of connection to the grid via orders using setpoints and gradients.

(3) Synchronous Renewable Power Plants shall be equipped with a permanent automatic excitation control system that can provide constant alternator terminal voltage at a selectable setpoint without instability over the entire operating range of

the synchronous Renewable Power Plants. The specifications and performance of the excitation control system shall include:

(a) bandwidth limitation of the output signal to ensure that the highest frequency of response cannot excite torsional oscillations on other *Power Plant*s connected to the network;

(b) an underexcitation limiter to prevent the AVR from reducing the alternator excitation to a level which would endanger synchronous stability;

(c) an overexcitation limiter to ensure that the alternator excitation is limited to less than the maximum value that can be achieved whilst ensuring that the synchronous *Renewable Power Plant* is operating within its design limits;

(d) a stator current limiter;

(4) The reactive power and voltage control functions are mutually exclusive, which means that only one of the three functions mentioned below can be activated at a time.

(a) Voltage control

(b) Power Factor control

(c) Q control

(5) The control function and applied parameter settings for reactive power and voltage control functions shall be determined by the *Marshalls Energy Company* and implemented by the *Renewable Power Plant*s. The agreed control functions shall be documented in the *operating agreement*.

7.1 Reactive power (Q) Control

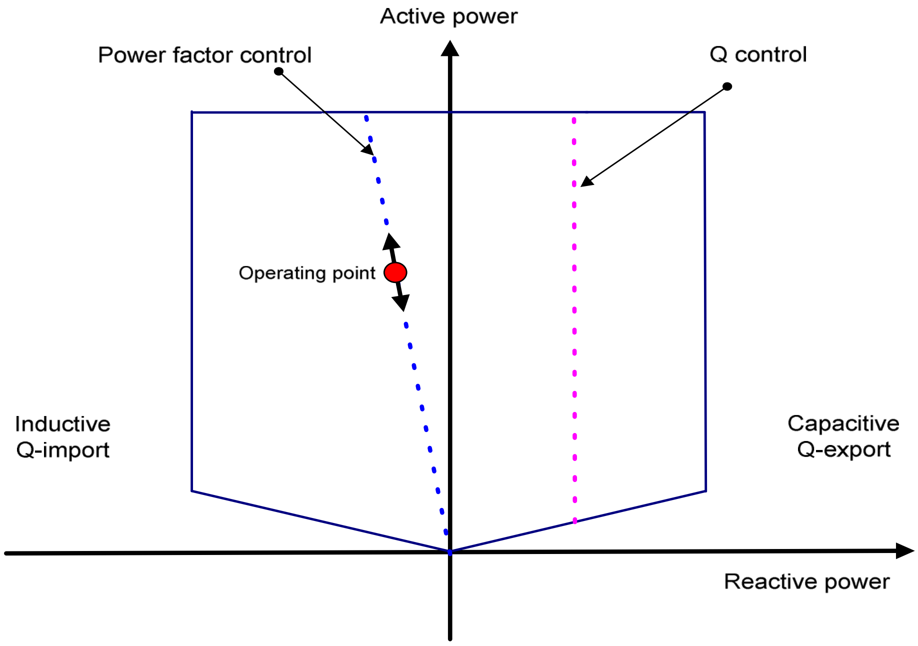
(1) Q control is a control function controlling the reactive power supply and absorption at the point of connection to the grid independently of the active power and the voltage. This control function is illustrated in Figure 4 as a vertical line.

(2) If the Q control setpoint is to be changed by the *Marshalls Energy Company*, the *Renewable Power Plant* shall update its echo analogue setpoint value in response to the new value within 1 second. The *Renewable Power Plant*s shall respond to the new set point within 30 seconds after receipt of an order to change the setpoint.

(3) The accuracy of the control performed and of the setpoint shall not deviate by more than ±2% of the setpoint value or by ±0.5% of maximum reactive power, depending on which yields the highest tolerance.

(4) The *Renewable Power Plant*s shall be able to receive a Q setpoint with an accuracy of at least ±0.5% of maximum reactive power.

Figure 4: Reactive power control functions for the *Renewable Power Plant*s



7.2 Power Factor Control

(1) Power Factor Control is a control function controlling the reactive power proportionally to the active power at the point of connection to the grid. This is illustrated in Figure 4 by a line with a constant gradient.

(2) If the power factor setpoint is to be changed by the *Marshalls Energy Company*, the *Renewable Power Plant* shall update its echo analogue setpoint value to in response to the new value within 1 second. The *Renewable Power Plant* shall respond to the new set point within 30 seconds after receipt of an order to change the setpoint.

(3) The accuracy of the control performed and of the setpoint shall not deviate by more than ±0.02.

7.3 Voltage Control

(1) Voltage control is a control function controlling the voltage at the point of connection to the grid.

(2) If the voltage setpoint is to be changed, such change shall be commenced within 1 second and completed no later than 30 seconds after receipt of an order to change the setpoint.

(3) The accuracy of the voltage setpoint shall be within ±0.5% of nominal voltage, and the accuracy of the control performed shall not deviate by more than ±2% of the required injection or absorption of reactive power according to *droop* characteristics as defined in Figure 5.

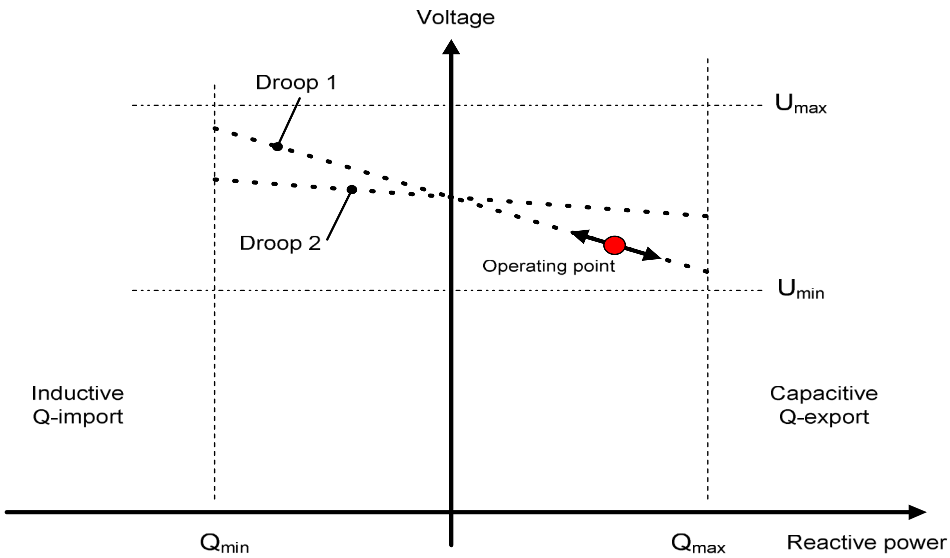
(4) The individual *Renewable Power Plant* shall be able to perform the control within its dynamic range and voltage limit with the *droop* configured as shown in Figure 5. In

this context, *droop* is the voltage change (p.u.) caused by a change in reactive power (p.u.).

(5) When the voltage control has reached the *Renewable Power Plant's* dynamic design limits, the control function shall await possible overall control from the tap changer or other voltage control functions.

(6) Overall voltage coordination shall be handled by the *Marshalls Energy Company*.

Figure 5: Voltage control for the *Renewable Power Plant*



8 <u>Power Quality</u>

(1) The following requirements shall apply to all *Renewable Power Plants*.

(2) *Power quality* and voltage regulation impact shall be monitored at the point of connection to the grid and shall include an assessment of the impact on *power quality* from the *Renewable Power Plant* concerning the following disturbances at the point of connection to the grid*:*

(a) voltage fluctuations:

(i) rapid voltage changes

(ii) flicker

(b) high-frequency currents and voltages:

(i) harmonics

(ii) inter-harmonics

(iii) disturbances greater than 2 kHz.

(c) unbalanced currents and voltages:

(i) deviation in magnitude between three phases

(ii) deviation in angle separation from 120° between three phases.

(3) The *Renewable Power Plant* and its interconnection system shall not inject dc current greater than 0.5% of the full rated output current at the point of connection.

(4) When the *Renewable Power Plant* is serving balanced linear loads, harmonic current injection into the network at the point of connection shall not exceed the limits stated below in Table 3. The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in the network without the *Renewable Power Plant* connected.

Table 3—Maximum harmonic current distortion in percent of current (I)[a]

Individual harmonic order h (odd harmonics)[b]	h < 11	11 ≤ h < 17	17 ≤ h < 23	23 ≤ h < 35	35 ≤ h	Total demand distortion (TDD)
Percent (%)	4.0	2.0	1.5	0.6	0.3	5.0

[a] I = the greater of the local network maximum load current integrated demand (15 or 30 minutes) without the RPP unit, or the RPP unit rated current capacity (transformed to the point of connection when a transformer exists between the RPP unit and the point of connection).

[b]Even harmonics are limited to 25% of the odd harmonic limits above.

(5) *Power quality* and voltage regulation impact shall be monitored at the point of connection to the grid.

(6) Voltage and current quality distortion levels emitted by the *Renewable Power Plant* at the point of connection to the grid shall not exceed the apportioned limits as determined by the *Marshalls Energy Company*.

(7) The *Renewable Power Plant* shall ensure that the *plant* is designed, configured and implemented in such a way that the specified emission limit values are not exceeded.

(8) The maximum allowable voltage change at the *Renewable Power Plant* after a switching operation by the *plant* (e.g. of a compensation devices) shall not be greater than 2%.

9 Islanding

(1) For an unintentional island in which the *Renewable Power Plant* energizes a portion of the network through the *point of connection*, the *Renewable Power Plant* interconnection system shall detect the island and cease to energize the network within two seconds of the formation of an island.

(2) *Renewable Power Plant* can be requested to intentionally island under certain conditions. The *Renewable Power Plant* requested to intentionally island shall have the facilities to detect an island condition, and have the capability to actively control frequency and / or voltage. *Marshalls Energy Company* shall provide the conditions and requirements from the for *Renewable Power Plant* intentional islanding.

10 Protection and Fault levels

(1) Unless otherwise stated, requirements in this section apply to all *Types* of *Renewable Power Plants*.

(2) Protection functions shall be available to protect the *Renewable Power Plant* and to ensure a stable network.

(3) The *Renewable Power Plants* shall ensure that the plant is dimensioned and equipped with the necessary protection functions such that the *plant* is protected against damage due to faults and incidents in the network.

(4) Protection schemes may cover the following aspects:

- external and internal short circuit,
- asymmetric load (negative phase sequence),
- stator and rotor overload,
- over-/underexcitation,
- over-/undervoltage at the connection point,
- over-/undervoltage at the alternator terminals,
- inrush current,
- asynchronous operation (pole slip),
- protection against inadmissible shaft torsions (for example, subsynchronous resonance),
- *power-generating module* line protection,
- unit transformer protection,
- back-up against protection and switchgear malfunction,
- overfluxing (U/f),
- inverse power,
- rate of change of frequency, and
- neutral voltage displacement.

(5) The *Marshalls Energy Company* may request that the set values for protection functions be changed following commissioning if it is deemed to be of importance to the operation of the network. However, such change shall not result in the *Renewable Power Plants* being exposed to negative impacts from the network lying outside of the design requirements.

(6) The *Marshalls Energy Company* shall inform the *Renewable Power Plants* owners/operators of the highest and lowest short-circuit current that can be expected at the point of connection to the grid as well as any other information about the network as may be necessary to define the *Renewable Power Plant's* protection functions.

11 Active Power Constraint Functions

(1) This section shall apply to Types B and C *Renewable Power Plants.*

(2) For system security reasons it may be necessary for the *Marshalls Energy Company* to curtail the *Renewable Power Plant's* active power output.

(3) The *Renewable Power Plants* shall be capable of:

(a) operating the plant at a reduced level if active power has been curtailed by the *Marshalls Energy Company* for system security reasons and for frequency control.

(b) receiving a telemetered MW Curtailment set-point sent from the *Marshalls Energy Company.*

(4) The *Renewable Power Plants* shall be equipped with constraint functions, i.e. supplementary active power control functions. The constraint functions are used to avoid imbalances in the *Marshalls Energy Company's* network or overloading of the network in connection with the reconfiguration of the network in critical or unstable situations or the like, as illustrated in Figure 6.

(5) Activation of the active power constraint functions shall be agreed with the *Marshalls Energy Company*.

The required constraint functions are as follows:

(a) Absolute production constraint

(b) Delta production constraint

(c) Power gradient constraint

(6) The required constraint functions are described in the following sections.

11.1 Absolute Production Constraint

(1) An Absolute Production Constraint is used to constrain the output active power from the *Renewable Power Plants* to a predefined power MW limit at the point of connection to the grid. This is typically used to protect the network against overloading and for frequency control.

(2) If the setpoint for the Absolute Production Constraint is to be changed, such change shall be commenced within 1 second and completed not later than 2 seconds after receipt of an order to change the setpoint.

(3) The accuracy of the control performed and of the setpoint shall not deviate by more than ±2% of the setpoint value or by ±0.5% of the *rated power,* depending on which yields the highest tolerance.

11.2 Delta Production Constraint

(1) A Delta Production Constraint is used to constrain the active power from the *Renewable Power Plants* to a required constant value in proportion to the possible active power.

(2) A Delta Production Constraint is typically used to establish a control reserve for control purposes in connection with primary frequency control.

(3) If the setpoint for the Delta Production Constraint is to be changed, such change shall be commenced within 1 second and completed no later than 2 seconds after receipt of an order to change the setpoint.

(4) The accuracy of the control performed and of the setpoint shall not deviate by more than ±2% of the setpoint value or by ±0.5% of the rated power, depending on which yields the highest tolerance.

11.3 Power Gradient Constraint

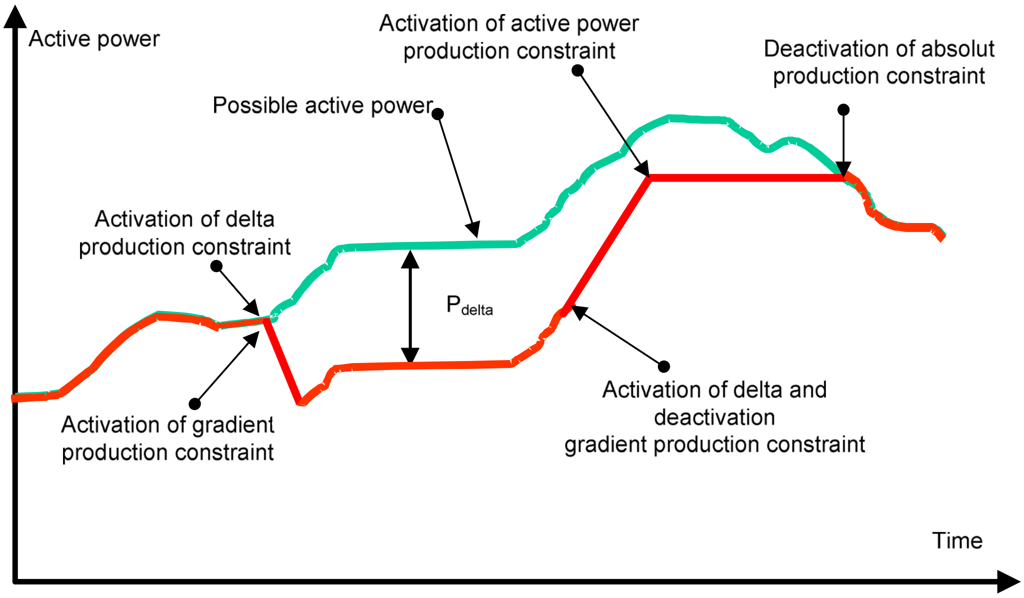
(1) A Power Gradient Constraint is used to limit the maximum ramp rates by which the active power can be changed in the event of changes in primary renewable energy supply or the setpoints for the *Renewable Power Plant.* A Power Gradient Constraint is typically used for reasons of system operation to prevent changes in active power from impacting the stability *of the* network.

(2) If the setpoint for the Power Gradient Constraint is to be changed, such change shall be commenced within 1 second and completed no later than 2 seconds after receipt of an order to change the setpoint.

(3) The accuracy of the control performed and of the setpoint shall not deviate by more than ±2% of the setpoint value or by ±0.5% of the *rated power,* depending on which yields the highest tolerance.

(4) The active power constraint functions are illustrated in **Figure 6**.

Figure 6: Active power control functions for a Renewable Power Plant



12 Control Function Requirements

(1) *Renewable Power Plants* shall be equipped with the control functions specified in Table 4. The purpose of the various control functions is to ensure overall control and monitoring of the *Renewable Power Plant's* generation.

(2) The *Renewable Power Plants* control system shall be capable of controlling the ramp rate of its active power output with a maximum MW per minute ramp rate set by the *Marshalls Energy Company*.

(3) These ramp rate settings shall be applicable for all ranges of operation including positive ramp rate during start up, positive ramp rate only during normal operation and negative ramp rate during controlled shut down. They shall not apply to frequency regulation.

(4) The *Renewable Power Plants* shall not perform any frequency response or voltage control functions without having entered into a specific agreement to this effect with the *Marshalls Energy Company*.

(5) The specifications and regulation functions specified shall comply with the international standard IEC 61400-25-2.

Table 4: Control functions required for *Renewable Power Plants*

Control function	Type A	Type B	Type C
Frequency control	X	X	X
Absolute production constraint	-	X	X

Control function	Type A	Type B	Type C
Delta production constraint	-	X	X
Power gradient constraint	-	X	X
Q control	-	X	X
Power factor control	-	X	X
Voltage control	-	X	X

13 Signals, Communications & Control

(1) All signals shall be made available at the *point of connection to the grid* by the *Renewable Power Plants*.

13.1 Signals from the *Renewable Power Plants* available at the point of connection to the grid

(1) This section shall apply to *Renewable Power Plants* of *Type B and C*.

(2) Signals from the *Renewable Power Plants* to the *Marshalls Energy Company* shall be broken up into a number of logical groups depending on functionality.

(3) The following signal list groups shall apply:

(a) ***Signals List #1** – General*

In addition, *Renewable Power Plants* shall be required to provide certain signals from Signals Lists 2, 3, 4 and 5. These lists relate to:

(b) ***Signals List #2** – Renewable Power Plant Availability Estimate;*

(c) ***Signals List #3** – Renewable Power Plant MW Curtailment data;*

(d) ***Signals List #4** – Renewable Power Plant frequency response settings*

(e) ***Signals List #5** – Renewable Power Plant meteorological data.*

13.1.1 Signals List #1 – General

(1) The *Renewable Power Plants* shall make the following signals available at the *Marshalls Energy Company* designated *communication gateway equipment* located at the *plant's* site:

(a) Actual sent-out (MW) at the point of connection to the grid

(b) Active Power Ramp rate of the entire *Renewable Power Plant*

(c) Reactive Power Import/Export (+/-*MVAr*) at the point of connection to the grid

(d) Reactive power range upper and lower limits

(e) *Power Factor*

(f) *Voltage output*

(g) *Echo MW set point*

(h) *Echo MVAr set point*

(i) *Echo Voltage set point*

13.1.2 Signals List #2 – *Renewable Power Plants* Current Availability Estimates

(1) The *Renewable Power Plants* shall make available the following signals at the *Marshalls Energy Company* designated *communication gateway equipment* located at the *plant* site:

(a) Current available maximum MW updated every second.

(b) Current available *MVA*r updated every second.

13.1.3 Signals List #3 – *RPP* MW Curtailment Data

(1) The *Renewable Power Plants* shall make the following signals available at a designated *communication gateway equipment* located at the *plant's* site:

(a) *Plant* MW Curtailment facility status indication (ON/OFF) as a double bit point. This is a controllable point which is set on or off by the *Marshalls Energy Company*. When set "On" the *plant* shall then clarify and initiate the curtailment based on the curtailment setpoint value below.

(b) Curtailment in progress digital feedback. This single bit point will be set high by the *plant* while the facility is in the process of curtailing its output.

(c) *Plant's* MW Curtailment Set-point value (MW- feedback).

(2) In the event of a curtailment, the Marshalls Energy Company will pulse the curtailment setpoint value down. The *plant's* response to the changed curtailment value will be echoed by changing the corresponding echo MW value. This will provide feedback that the *plant* is responding to the curtailment request.

13.1.4 Signals List #4 – Frequency Response System Settings

(1) The *Renewable Power Plants* shall make the following signals available at a designated communication gateway equipment located at the *plant's* site:

(a) *Frequency Response System* mode status indication (ON/OFF) as a double bit point

13.1.5 Signals List #5 – Renewable Power Plants Meteorological Data.

(1) *Renewable Power Plants* shall make the following signals available at the *Marshalls Energy Company's* designated communication gateway equipment located at the *plant* site:

(a) Wind speed (within 75% of the hub height) – measured signal in meters/second (for *WPP only*)

(b) Wind direction within 75% of the hub height) – measured signal in degrees from true north(0-359) (for *WPP only*)

(c) Air temperature- measured signal in degrees centigrade (-20 to 50)

(d) Air pressure- measured signal in millibar (800 to 1400).

(e) Air density (for *WPP only*)

(f) Solar radiation (for *PVPP only*)

(2) The meteorological data signals shall be provided by a dedicated Meteorological Mast located at the *plant's* site or, where possible and preferable to do *so*, data from a means of the same or better accuracy.

(3) Energy resource conversion data for the facility (e.g. MW/ wind speed) for the various resource inputs to enable the *Marshalls Energy Company* to derive a graph of the full range of the facilities output capabilities. An update will be sent to the *Marshalls Energy Company* following any changes in the output capability of the facility.

13.2 Update Rates

(1) Signals shall be updated at the following rates:

(a) Analog Signals at a rate of 1 second

(b) Digital Signals at the rate of 1 second.

(c) Meteorological data once a minute

13.3 Control Signals Sent from *Marshalls Energy Company* to the *Renewable Power Plants*

The control signals described below shall be sent from *Marshalls Energy Company* to the *Type B and C Renewable Power Plants*. The *plants* shall be capable of receiving these signals and acting accordingly.

13.3.1 Active-Power Control

(1) An *Active-Power Control* setpoint signal shall be sent by *Marshalls Energy Company* to the *Renewable Power Plant's* control system.

(2) This setpoint shall define the maximum Active Power output permitted from the *plant*. The *plant's* control system shall be capable of receiving this signal and acting accordingly to achieve the desired change in Active Power output.

(3) The *Renewable Power Plants* shall make it possible for the *Marshalls Energy Company* to remotely enable/disable the Active-Power control function in the plant's control system.

13.3.2 Connection Point CB Trip facility

(1) A facility shall be provided by the *Marshalls Energy Company* to facilitate the disconnection of the *plant*. It shall be possible for Marshalls Energy Company to send a trip signal to the circuit breaker at the *HV* side of *the point of connection to the grid.*

13.3.3 Synchronisation block signal

(1) A Synchronisation block signal shall be sent by *Marshalls Energy Company* to the *Renewable Power Plant's* control system to prevent the *Renewable Power Plant* from synchronising when system conditions dictate this.

13.4 *Renewable Power Plants* MW availability declaration

(1) The *Renewable Power Plant* shall submit *plant's* MW availability declarations whenever changes in MW availability occur or are predicted to occur. These declarations shall be submitted by means of an electronic interface in accordance with the requirements of *Marshalls Energy Company's* data system.

13.5 Data Communications Specifications

(1) The *Renewable Power Plant* shall have external communication gateway equipment that can communicate with a minimum of two simultaneous SCADA Masters, independently from what is done inside the *plant*.

(2) The location of the communication gateway equipment shall be agreed between affected participants in the connection agreement.

(3) The necessary communications links, communications protocol and the requirement for analogue or digital signals shall be specified by the *Marshalls Energy Company* as appropriate before a connection agreement is signed between the *plant* and the *Marshalls Energy Company*.

(4) *Active Power Curtailment* or *Voltage Regulation* facilities at the *plant* shall be tested once a quarter. It is essential that facilities exist to allow the testing of the functionality without tripping the actual equipment.

(5) Where signals or indications required to be provided by the *plant* become unavailable or do not comply with applicable standards due to failure of the *plant* equipment or any other reason under the control of the *plant owner/operator*, the *plant owner/operator* shall restore or correct the signals and/or indications within 24 hours.

14 Testing and Compliance Monitoring

(1) All *Renewable Power Plants* shall demonstrate compliance to all applicable requirements specified in this grid connection code and any other applicable code or standard, before being allowed to connect to the network.

(2) The *plant* shall review, and confirm to the *Marshalls Energy Company*, compliance by the *plant* with every requirements of this code.

(3) The *Renewable Power Plant* shall conduct tests or studies to demonstrate that the *plant* complies with each of the requirements of this code.

(4) The *Renewable Power Plant* shall continuously monitor its compliance in all material respects with all the connection conditions of this code.

(5) Each *Renewable Power Plant* shall submit to the *Marshalls Energy Company* a detailed test procedure, emphasising system impact, for each relevant part of this code prior to every test.

(6) If *Renewable Power Plant* determines, from tests or otherwise, that the *plant* is not complying with one or more sections of this code, then the *plant owner/operator* shall (within 1 hour of being aware):

(a) notify the *Marshalls Energy Company* of that fact,

(b) advise the *Marshalls Energy Company* of the remedial steps it proposes to take to ensure that the relevant *plant* can comply with this code and the proposed timetable for implementing those steps,

(c) diligently take such remedial action to ensure that the relevant *plant* can comply with this code; the *plant owner/operator* shall regularly report in writing to the Marshalls Energy Company on its progress in implementing the remedial action, and

(d) after taking remedial action as described above, demonstrate to the reasonable satisfaction of the *Marshalls Energy Company* that the relevant *plant* is then complying with this code.

(7) The *Marshalls Energy Company* may issue an instruction requiring the *plant* to carry out a test to demonstrate that the relevant *plant* with the code requirements. A *plant* may not refuse such an instruction, provided it is issued timeously and there are reasonable grounds for suspecting non-compliance.

(8) The *plant* owner/operator shall keep records relating to the compliance of the *plant* with each section of this grid connection code, or any other code applicable to that *plant*, setting out such information that the *Marshalls Energy Company* reasonably requires for assessing power system performance, including actual *plant* performance during abnormal conditions. Records shall be kept for a minimum of 5 years (unless otherwise specified in the code) commencing from the date the information was created.

15 Reporting to Marshalls Energy Company

(1) The *Renewable Power Plant* shall design the system and maintain records *such* that the following information can be provided to the *Marshalls Energy Company* on a monthly basis in an electronic spread sheet format:

(a) Non-renewable/supplementary fuel used by the power plant.

(b) Actual hourly availability and output energy to the grid that occurred and the average primary resource for that hour.

(c) Actual hourly electricity imports from all sources as applicable.

(d) Any curtailed energy during the month.

(2) These reports are to be submitted before the 15th of the following month to *Marshalls Energy Company* via an email.

(3) These reports should also include details of incidents relating any unavailability of the network which prevented the *plant* from generating.

(4) The *Marshalls Energy Company* requires suitable and accurate dynamic models, in the template specified by the requesting party applying for a connection to the *network*, in order to assess reliably the impact of the *plant* proposed installation on the dynamic performance and security and stability of the power system.

(5) The required dynamic models must operate under RMS simulation to replicate the performance of the *plant* or individual units for analysis of the following network aspects:

(a) *Plant's* impact on network voltage stability

(b) *Plant's* impact on Quality of Supply at *point of connection*

(c) *Plant's* impact on network protection co-ordination

(d) *Plant's FRT* (Fault Ride Through) capability for different types of faults and positions (h) *plant's* response to various system phenomena such as:

(i) switching on the network

(ii) power swings

(iii) small signal instabilities

(6) *Plant's* data exchange shall be a time-based process.

(a) **First stage** (during the application for connection)

(i) The following information shall be submitted by the *plant owner/operator* to the *Marshalls Energy Company*, as applicable:

- Physical location (including the GPS coordinates)

- Site Plan
- Number of wind turbines or *units* to be connected
- MW output per turbine or *unit*
- Initial phase MW value
- Final phase MW value and timelines
- Any other information that the service provider may reasonably require

(ii) For the detailed *plant* design, the *Marshalls Energy Company* shall make available to the *plant owner/operator* at least the following information:

- *Point of connection* to the grid including the nominal voltages,
- Expected fault levels,
- The network service provider's connection between the Point of connection to the grid and the *plant*,
- The busbar layout of the point of connection to the grid and *point of connection* substations,
- The portion of the network service provider's grid that will allow accurate and sufficient studies to design the *plant* to meet the Grid Code. This information shall include:
    - o Positive and zero sequence parameters of the relevant network service provider's transmission and distribution, transformers, reactors, capacitors and other relevant equipment
    - o The connection of the various lines transformers, reactors and capacitors etc.

(b) **Second stage** (after detailed *plant* designs have been completed but before commissioning the *plant*)

(i) During this stage, the *plant* shall provide information on:

- Selected *plant* technology data.
- Fault ride through capability and harmonic studies test report
- Generic test model and dynamic modelling data per wind turbine or *unit* as from the type approval and tests result

(c) **Third stage** (after commissioning and optimisation of the *plant*)

(i) During this stage, the *plant* is compelled to provide information on:

- A validated *plant's* electrical dynamic simulation model using commissioning test data and measurements

- Test measurement data in the format agreed between the *plant* and the Marshalls Energy Company, as applicable.

(7) The dynamic modelling data shall be provided in a format as may be agreed between the *plant owner/operator* and the Marshalls Energy Company, as applicable.

(8) In addition, the *Renewable Power Plant* Generator shall provide the Marshalls Energy Company with operational data as prescribed in **Appendix 4**.

16 Appendix 1 - *Wind Power Plants*

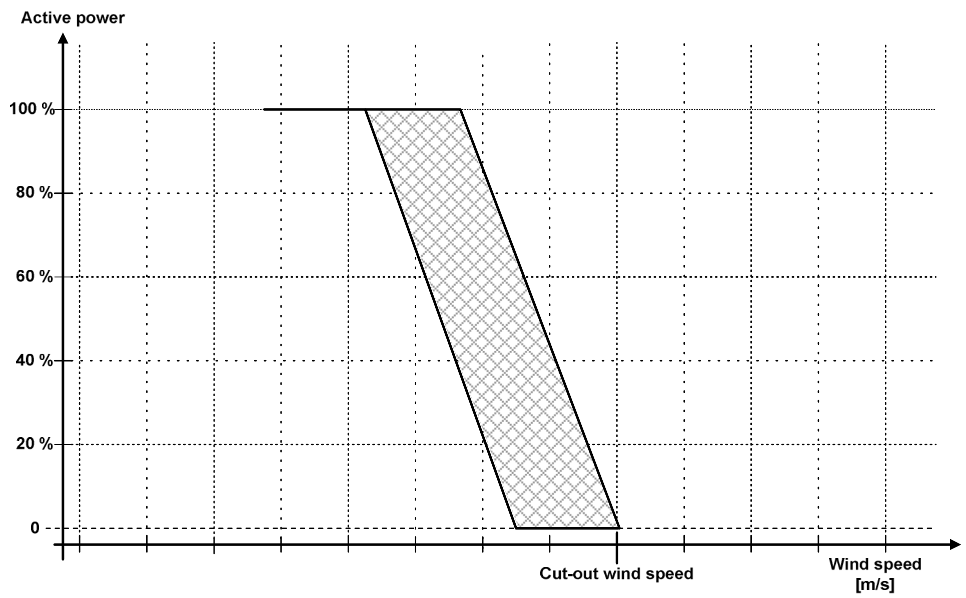
16.1 High Wind Curtailment

(1) It shall be possible to continuously downward regulate the active power supplied by the *plant* to an arbitrary value in the interval from 100% to at least 40% of the rated power. When downward regulation is performed, the shutting-down of individual wind turbine *generator* systems is allowed *so* that the load characteristic is followed as well as possible.

(2) The *Wind Power Plant* shall stay connected to the *network* at average wind speeds below a predefined cut-out wind speed. The cut-out wind speed shall as a minimum be 25 m/s, based on the wind speed measured as an average value over a 10-minute period. To prevent instability in the *network*, the *Wind Power Plant* shall be equipped with an automatic downward regulation function making it possible to avoid a temporary interruption of the active power production at wind speeds close to the cut-out wind speed.

(3) Downward regulation shall be performed as continuous or discrete regulation. Discrete regulation shall have a step size of maximum 25% of the rated power within the hatched area shown in Figure 7. When downward regulation is being performed, the shutting down of individual wind turbine *generator* systems is allowed. The downward regulation band shall be agreed with the *Marshalls Energy Company* upon commissioning of the wind power plant.

Figure 7: Downward regulation of active power at high renewable speeds



17 Appendix 2 - *Photovoltaic Power Plants*

No special requirements for solar PV except the general requirement specified in this code.

Appendix 3 - *Battery Power Plants*

No special requirements for *Battery Power Plants* except the general requirement specified in this code.

18 Appendix 4 - Documentation

18.1 Master Data

Description	Text
Identification:	
Name of *electricity supply undertaking*	
Plant name	
ID number	
Planned commissioning	
Technical data:	
Manufacturer	
Type designation (model)	
Type approval	
Approval authority	
Installed kW (*rated power*)	
Cos φ (*rated power*)	
Cos φ (20% *rated power*)	
Cos φ (no load)	
3-phase short-circuit current immediately in front of the *power plant* (RMS)	
Point of connection	
Voltage level	

Description	Text
Plant address:	
Contact person (technical)	
Address1	
House number	
Letter	
Postal code	
BBR municipality	
X/Y coordinates	
Title number	
Owners' association on titled land	
Owner:	
C ID number	
Company name	
Contact person (administrative)	
Address1	
House number	
Letter	
Floor	
To the right/left	
Postal code	
Email address	

18.2 Technical Documentation

18.2.1 Step-Up Transformer

Description	**Value**
Make	
Type	
Comments	

Description	**Symbol**	**Unit**	**Value**
Nominal apparent power (1 p.u.)	S_n	*MVA*	
Nominal primary voltage (1 p.u.)	U_p	kV	
Nominal secondary voltage	U_s	kV	
Coupling designation, eg Dyn11	-	-	
Step switch location	-	-	Primary side ☐ Secondary side ☐
Step switch, additional voltage per step	du_{tp}	%/trin	
Step switch, phase angle of additional voltage per step:	phi_{tp}	degree/step	
Step switch, lowest position	n_{tpmin}	-	
Step switch, highest position	n_{tpmax}	-	
Step switch, neutral position	n_{tp0}	-	
Short-circuit voltage, synchronous	u_k	%	
Copper loss	P_{cu}	kW	
Short-circuit voltage, zero system	u_{k0}	%	
Resistive short-circuit voltage, zerosequence system	u_{kr0}	%	
No-load current	I_0	%	
No-load loss	P_0	%	

18.2.2 Single Line Diagram Representation

(1) This applies to all *Renewable Power Plants* of Type B and C.

(2) A single-line diagram representation of the plant shall be created, with indication of *point of connection to the grid,* metering points, including settlement metering, limits of ownership and operational supervisor limits/limits of liability. In addition, the type designation for the switchgear used shall be stated *so* as to make it possible to identify the correct connection terminals.

(3) In instances when a single-line diagram representation is included in the grid use agreement between the *Renewable Power Plant* and Marshalls Energy Company, the grid *connection agreement* can be enclosed as documentation.

18.2.3 PQ Diagram

(1) This applies to all *Renewable Power Plants* of Type B and C.

19 Appendix 5 – Compliance test specifications

19.1 Introduction

This section specifies the procedures to be followed in carrying out testing to verify compliance with this *Code.*

19.2 Test procedures

19.3 *Renewable Power Plants* protection function verification

Parameter	Reference	Description
Protection function and settings	Section 9	**APPLICABILITY AND FREQUENCY** All new *Renewable Power Plants* coming on line or at which major refurbishment or upgrades of protection systems have taken place. **Routine review:** All *plants* to confirm compliance every six years. **PURPOSE** To ensure that the relevant protection functions in the *Renewable Power Plants* are coordinated and aligned with the system requirements. **PROCEDURE** 1. Establish the system protection function and associated trip level requirements from the *Marshalls Energy Company*. 2. Derive protection functions and settings that match the *Renewable Power Plant* and system requirements. 3. Confirm the stability of each protection function for all relevant system conditions. 4. Document the details of the trip levels and stability calculations for each protection function. 5. Convert protection tripping levels for each protection function into a per *unit* base. 6. Consolidate all settings in a per *unit* base for all protection functions in one document. 7. Derive actual relay dial setting details and document the relay setting sheet for all protection functions. 8. Document the position of each protection function on one single line diagram of the generating *unit* and associated connections. 9. Document the tripping functions for each tripping function on one tripping logic diagram. 10. Consolidate detail setting calculations, per unit setting sheets, relay setting sheets, plant base information on which the settings are based, tripping logic diagram, protection function single line diagram and relevant

		protection relay manufacturers' information into one document. *11.*Submit to the *Marshalls Energy Company* for its acceptance and update.
Protection function and settings (cont.)	Section 9 (cont.)	**Review:** 1. Review Items 1 to 10 above. Submit to the *Marshalls Energy Company* for its acceptance and update. Provide the *Marshalls Energy Company* with one original master copy and one working copy. **ACCEPTANCE CRITERIA** All protection functions are set to meet the necessary protection requirements of the *plant* with a minimal margin, optimal fault clearing times and maximum plant availability. Submit a report to the *Marshalls Energy Company* one month after commissioning and six-yearly for routine tests.

19.3.1 *Renewable Power Plants* protection integrity verification

Parameter	Reference	Description
Protection integrity	Section 9	**APPLICABILITY AND FREQUENCY** All new *Renewable Power Plants* coming on line and all other *power stations* after major works of refurbishment of protection or related plant. Also, when modification or work has been done to the protection, items 2 to 5 must be carried out. This may, however, be limited to the areas worked on or modified. **Routine review:** All *plants* on: item 1 below: Review and confirm every 6 years Item 2, and 3 below: at least every 12 years. **PURPOSE** To confirm that the protection has been wired and functions according to the specifications. **PROCEDURE** 1. Apply final settings as per agreed documentation to all protection functions. 2. With the *unit* off load and de-energized, inject appropriate signals into every protection function and confirm correct operation and correct calibration. Document all protection function operations. 3. Carry out trip testing of all protection functions, from origin (e.g. Buchholz relay) to all tripping output devices (e.g. HV breaker). Document all trip test responses. 4. Apply short-circuits at all relevant protection zones and with *generator* at nominal speed excite *generator* slowly, record currents at all relevant protection functions and confirm correct operation of all relevant protection functions. Document all readings and responses. Remove all short-circuits. 5. With the *Renewable Power Plants* at nominal production. Confirm correct operation and correct calibration of all protection functions. Document all readings and responses.

		Review: Submit to the *Marshalls Energy Company* for its acceptance and update. **ACCEPTANCE CRITERIA** All protection functions are fully operational and operate to required levels within the relay *OEM* allowable tolerances. Measuring instrumentation used shall be sufficiently accurate and calibrated to a traceable standard. Submit a report to the *Marshalls Energy Company* one month after test.

19.3.2 - *Renewable Power Plants* active power control capability verification

Parameter	Reference	Description
Active power control function and operational range	Section 10 depending on Type	**APPLICABILITY** All new *Renewable Power Plants* coming on line and after major modifications or refurbishment of related plant components or functionality. **Routine test/reviews**: Confirm compliance every 6 years. **PURPOSE** To confirm that the active power control capability specified is met. **PROCEDURE** The following tests shall be performed within an active power level range of at least 0.2p.u.or higher 1. The *plant* will be required to regulate the active power to a set of specific setpoints within the design margins. 2. The *plant* will be required to obtain a set of active power setpoints within the design margins with minimum two different gradients for ramping up and two different gradients for ramping down. 3. The *plant* will be required to maintain as a minimum two different set levels of spinning reserve within the design margins. 4. The *plant* will be required to operate as a minimum to limit active power output according to two different absolute power constraint set levels within the design margins. 5. The *plant* will be required to verify operation according to as a minimum two different parameter sets for a frequency response curve within the design margins. **ACCEPTANCE CRITERIA**

		1. The *plant* shall maintain the set output level within ±2% of the capability registered with the *Marshalls Energy Company* for at least one hour. 2. The *plant* shall demonstrate ramp rates with precision within ±2% of the capability registered with the *Marshalls Energy Company* for ramp up and down. 3. The *plant* shall maintain a spinning reserve set level within ±2% of the capability registered with the *Marshalls Energy Company* for at least one hour. 4. The *plant* shall maintain an absolute power constraint set level within ±2% of the capability registered with the *Marshalls Energy Company* for at least one hour. 5. The *plant* shall demonstrate that the requested frequency response curves can be obtained. Submit a report to the *Marshalls Energy Company* one month after the test.

19.3.3 *Renewable Power Plants* reactive power control capability verification

Parameter	Reference	Description
Reactive power control function and operational range	Sections 6 and 7 depending on Type	**APPLICABILITY** All new *Renewable Power Plants* coming on line and after major modifications or refurbishment of related plant components or functionality. **Routine test/reviews**: Confirm compliance every 6 years. **PURPOSE** To confirm that the reactive power control capability specified is met. **PROCEDURE** The following tests shall be performed within a minimum active power level range of at least 0.2 p.u. or higher 1. The *plant* will be required to regulate the voltage at the point of connection to the grid to a set level within the design margins. 2. The *plant* will be required to provide a fixed Q to a set level within the design margins. 3. The *plant* will be required to obtain a fixed PF within the design margins. **ACCEPTANCE CRITERIA** 1. The *plant* shall maintain the set voltage within ±5% of the capability registered with the *Marshalls Energy Company* for at least one hour. 2. The *plant* shall maintain the set Q within ±2% of the capability registered with the *Marshalls Energy Company* for at least one hour. 3. The *plant* shall maintain the set PF within ±2% of the capability registered with the *Marshalls Energy Company* for at least one hour.

		Submit a report to the *Marshalls Energy Company* one month after the test.

19.3.4 *Renewable Power Plants* power quality calculations

Parameter	Reference	Description
Power quality calculations for:	Section 8 depending on Type	**APPLICABILITY** All new *plants* coming on line and after major modifications or refurbishment of related plant components or functionality. **Routine test/reviews**: Confirm compliance every 6 years. **PURPOSE** To confirm that the limits for all power quality parameters specified is met. **PROCEDURE** The following tests shall be calculated within a minimum active power level range from 0.2p.u. to 1.0p.u.
1. Rapid voltage changes		1. Calculate the levels for rapid voltage changes are within the limits specified over the full operational range.
2. Flicker		2. Calculate the flicker levels are within the limits specified over the full operational range.
3. Harmonics		3. Calculate the harmonics are within the limits specified over the full operational range.
4. Inter-harmonics		4. Calculate the interharmonics are within the limits specified over the full operational range.

5. High frequency disturbances		5. Calculate the disturbances higher than 2 Hz are within the limits specified over the full operational range. **ACCEPTANCE CRITERIA** 1. The calculations shall demonstrate that the levels for rapid voltage changes are within the limits specified over the full operational range. 2. The calculations shall demonstrate that the flicker levels are within the limits specified over the full operational range. 3. The calculations shall demonstrate that the harmonics are within the limits specified over the full operational range. 4. The calculations shall demonstrate that the interharmonics are within the limits specified over the full operational range. 5. The calculations shall demonstrate that the disturbances higher than 2 Hz are within the limits specified over the full operational range Submit a report to the *Marshalls Energy Company* one month after the test.

19.3.5 *Renewable Power Plants* fault ride through simulations

Parameter	Reference	Description
Simulations of fault ride though voltage droops and peaks.	Section 4	**APPLICABILITY** All new *plants* coming on line and after major modifications or refurbishment of related plant components or functionality. **Routine test/reviews**: None. **PURPOSE** To confirm that the limits for all power quality parameters specified is met. **PROCEDURE** By applying the electrical simulation model for the entire *plant* it shall be demonstrated that the *plant* performs to the specifications. 1. Area A - the *plant* shall stay connected to the network and uphold normal production. 2. Area B - the *plant* shall stay connected to the network. The *plant* shall provide maximum voltage support by supplying a controlled amount of reactive power within the design framework offered by the technology, see Figure 1. 3. Area C - the *plant* is allowed to disconnect. 4. Area D - the *plant* shall stay connected. The *plant* shall provide maximum voltage support by absorbing a controlled amount of reactive power within the design framework offered by the technology, see Figure 1. **ACCEPTANCE CRITERIA** 1. The dynamic simulations shall demonstrate that the *plants* fulfils the requirements specified. Submit a report to the *Marshalls Energy Company* three month after the commission.