D.1 Terms of Technical Requirements for Power Generating Modules

0. Amendments to the previous version

This is the second version of these Terms. Chapters 3 to 8 are based on Commission Regulation (EU) 2016/631 and hereby replace Chapters 3 to 8 in the previous version. The new definitions in Chapter 2 are in accordance with the amendments made to the aforementioned Chapters.

1. Inngangur

1.1 These Terms are set on the basis of paragraph 6 of Article 9 of the Electricity Act, No. 65/2003, as subsequently amended (referred to hereafter as the Electricity Act) and Article 6 of Regulation No. 513/2003, on system management in the electricity system.

1.2 These Terms are based on EU Regulation 2016/631 (17.05.2016) “Establishing a Network Code on Requirements for Grid Connection of Generators (RfG)” which is based on the proposals put forward by ENTSO-E.

1.3 These Terms have been confirmed by the Minister, pursuant to paragraph 6 of Article 9 of the Electricity Act.

2. Definitions

The following definitions apply in these Terms:

2.1 Power Factor: The ratio of the absolute value of active power to apparent power.

2.2 Houseload operation: The operation which ensures that power generating facilities are able to continue to supply their in-house loads in the event of network failures resulting in power generating modules being disconnected from the network.

2.3 Island operation: is the temporary operating mode of two or more transmission grid sections which have been (electrically) separated from each other and therefore become asynchronous.

2.4 Maximum Capacity ($P_{max)}$: The maximum continuous active power which a power-generating module can produce, less any demand associated solely with facilitating the operation of that power-generating module and not fed into the network as specified in the connection agreement or as agreed between the relevant system operator and the power-generating facility owner.

2.5 Symmetrical fault: a fault affecting all phases. An example is a three-phase short-circuit.

2.6 Reactive Power: The imaginary component of the apparent power at fundamental frequency, usually expressed in kilovar (1000 VAr) or megavar (1,000,000 MVAr).

2.7 Power Park Module (PPM): A unit or ensemble of units generating electricity, which is either non-synchronously connected to the network or connected through power electronics, and that also has a single connection point to a transmission system, distribution system including closed distribution system or HVDC system.

2.8 Asymmetric fault: A fault hat does not affect all phases. An example is a two-phase short-circuit.

2.9 Setpoint: The target value for any parameter typically used in control schemes

2.10 P-Q-Capability Diagram: A diagram describing the reactive power capability of a power generating module in the context of varying active power at the connection point.

2.11 Active Power: The real component of the apparent power at fundamental frequency, expressed in watts or multiples thereof such as kilowatts (1000 W) or megawatts (1,000,000 W).

2.12 Power System Stabilator (PSS): An additional functionality of the AVR of a synchronous power generating module whose purpose is to damp power oscillations.

2.13 Synchronous Power Generating Module: An indivisible set of installations which can generate electrical energy such that the frequency of the generated voltage, the generator speed and the frequency of network voltage are in a constant ratio and thus in synchronism.

2.14 Automatic Voltage Regulator (AVR): The continuously acting automatic equipment controlling the terminal voltage of a synchronous power generating module by comparing the actual terminal voltage with a reference value and controlling the output of an excitation control system.

2.15 Voltage: The difference in electrical potential between two points measured as the root-mean-square value of the positive sequence phase-to-phase voltages at fundamental frequency.

2.16 Fault-ride through: The capability of electrical devices to be able to remain connected to the network and operate through periods of low voltage at the connection point caused by secured faults.

2.17 Current: The rate at which electric charge flows which is measured by the root-mean-square value of the positive sequence of the phase current at fundamental frequency.

2.18 Fast Fault Current: A current injected by a power generating module during and after a voltage deviation caused by an electrical fault with the aim of identifying a fault by network protection systems at the initial stage of the fault supporting system voltage retention at a later stage of the fault and system voltage restoration after fault clearance.

2.19 Apparent Power The product of voltage and current at fundamental frequency, and the square root of three in the case of three-phase systems, usually expressed in kilovolt-amperes (1000 VA) or megavolt-amperes (1,000,000 VA).

2.20 Synthetic Inertia: The facility provided by a power park module or HVDC system to replace the effect of inertia of a synchronous power generating module to a prescribed level of performance.

2.21 Connection Point: The location point where an energy-intensive or distribution power generating module connects to Landsnet‘s transmission system.

2.22 Connection Agreement: is a contract between Landsnet and the owner of a power generating module which describes the connection and the necessary technical requirements.

2.23 Frequency: Is the electric frequency of the system expressed in hertz that can be measured in all parts of the synchronous area under the assumption of a consistent value for the system in the time frame of seconds, with only minor differences between different measurement locations. Its nominal value is 50Hz.

2.24 Frequency Sensitive Mode (FSM): The operating mode of a power generating module or HVDC system in which the active power output changes in response to a change in system frequency, in such a way that it assists with the recovery to target frequency.

2.25 Limited Frequency Sensitive Mode - Underfrequency (LFSM-U): A power generating module or HVDC system operating mode which will result in active power output increase in response to a change in system frequency below a certain value.

2.26 Limited Frequency Sensitive Mode Overfrequency: A power generating module or HVDC system operating mode which will result in active power output reduction in response to a change in system frequency above a certain value

2.27 Frequency Control: The capability of a power generating module or HVDC system to adjust its active power output in response to a measured deviation of system frequency from a setpoint, in order to maintain stable system frequency.

2.28 Inertia: The property of a rotating rigid body, such as the rotor of an alternator, such that it maintains its state of uniform rotational motion and angular momentum unless an external torque is applied.

2.29 U-Q/Pmax: A profile representing the reactive power capability of a power generating module or HVDC converter station in the context of varying voltage at the connection point.

2.30 A Power Generating Module is either:

- A Synchronous Power Generating Module
- A Power Park Module

2.31 A type B power generating module is a power generating module with an installed capacity of anything from 1.5 MW and up to 10 MW with a connection point of 66 kW or less.

2.32 A type D power generating module is a power generating module with an installed capacity of anything from 10 MW with a connection point of 66 kW or more.

2.33 A step change to voltage or frequency is a sudden and singular change from apriori steady-state voltage or frequency value to an aposteriori steady-state value of unknown time-length.

3. General

3.1 Landsnet is obligated by law to ensure the secure operation and stability of Iceland's transmission system. This includes technical requirements on production units.

3.2

These terms and conditions apply to all power generating modules with an installed capacity of 1.5 MW or more and which are directly connected to the transmission system. The terms solely apply to power generating modules taken into operation after the introduction of these Terms. However, these terms apply if a power generating module has been updated/refurbished and a new and extensively amended connection agreement is therefore required. If the owner of a power generating module has entered into a binding contract for the purchase of equipment for the power generating modules within two years of the implementation of these Terms, then the previous Terms apply

(i) Any refurbishment of power generating modules, which could affect its technical ability shall be reported to Landsnet well in advance

3.3 Power generating modules must have an accurate, stable and a highly steerable (real-time) rapid response to provide basic system management to ensure the security of supply. These requirements apply irrespective of the operating conditions of the transmission system and are in accordance with detailed requirements for power generating modules. The requirements should ensure the real-time response of the system to deal with events that may arise in the transmission system. The efficiancy of power generating modules must be sufficient enough to deal with disruptions and the need for information and steering/control should be sufficient to utilise the processing units under different conditions in the transmission system.

4. General requirements for power generating modules

4.1 Power Generating Modules shall fulfil the following requirements referring to Frequency:

a) Frequency:

(i) A Power Generating Module shall be capable of staying connected to the Network and operating within the Frequency ranges and time periods specified:

47.0-47.5 Hz	period of 20 s
47.5-52.0 Hz	unlimited period
52.0 – 53.0 Hz	period of 20 s

(ii) While respecting the provisions of Item 4.1) a) i) a Power Generating Module shall be capable of automatic disconnection at specified frequencies, if required by

Landsnet. Terms and settings for automatic disconnection shall be agreed between Landsnet and the Power Generating Facility Owner.

b) The power generating module shall be capable of remaining connected to the transmission system during any frequency changes up to a maximum of 0.5 Hz per second.

4.2 With regard to the limited frequency sensitive mode — overfrequency (LFSM-O), the following shall apply:

a) The Power Generating Module shall be capable of activating the provision of Active Power Frequency Response according to figure 1

b) The frequency threshold shall be between and including 50.2 Hz and 50.5 Hz

c) The droop range shall be adjustable and between 2-12% according to the s_2 index shown in figure 1. The actual Frequency threshold and Droop settings shall be determined by Landsnet

d) The Power Generating Module shall be capable of activating Active Power Frequency Response as fast as technically feasible with an initial delay that shall be as short as possible or within 2 seconds. Any delay greater than 2 seconds shall be reasonably justified by the Power Generating Facility Owner with the relavant documentation

e) Landsnet can require that a power generating module at Minimum Regulating Level be capable of the following:

i) Continuing operation at that level

ii) Further decreasing Active Power output

f) The Power Generating Module shall be capable of stable operation during LFSM-O operation. When LFSM-O is active, the LFSM-O Setpoint will prevail over any other Active Power Setpoints

4.3

The following shall apply accumulatively with regard to Limited Frequency Sensitive Mode – Underfrequency (LFSM-U) for Type D power generating modules:

a) The Power Generating Module shall be capable of activating the provision of Active Power Frequency Response according to figure 2 and in accordance with the following:

(i) The Power Generating Module shall be capable of activating the provision of Active Power Frequency Response at a threshold of between and including 49.8 Hz and 48 Hz

(ii) The droop range shall be adjustable and between 2-12% according to the s_2 index shown in figure 1. The actual Frequency threshold and Droop settings shall be determined by Landsnet

b) The actual delivery of active power frequency response in LFSM-U mode shall take into account:

(i) Ambient conditions such as meteorological conditions and water flow

(ii) The operational condition of the power generating modules, especially limitations to production close to the maximum production capacity and at low frequency. This includes the relevant environmental factors in accordance with Articles 4.5 and 4.6

Figure 1 Active power frequency response capability of power-generating modules in LFSM-O.

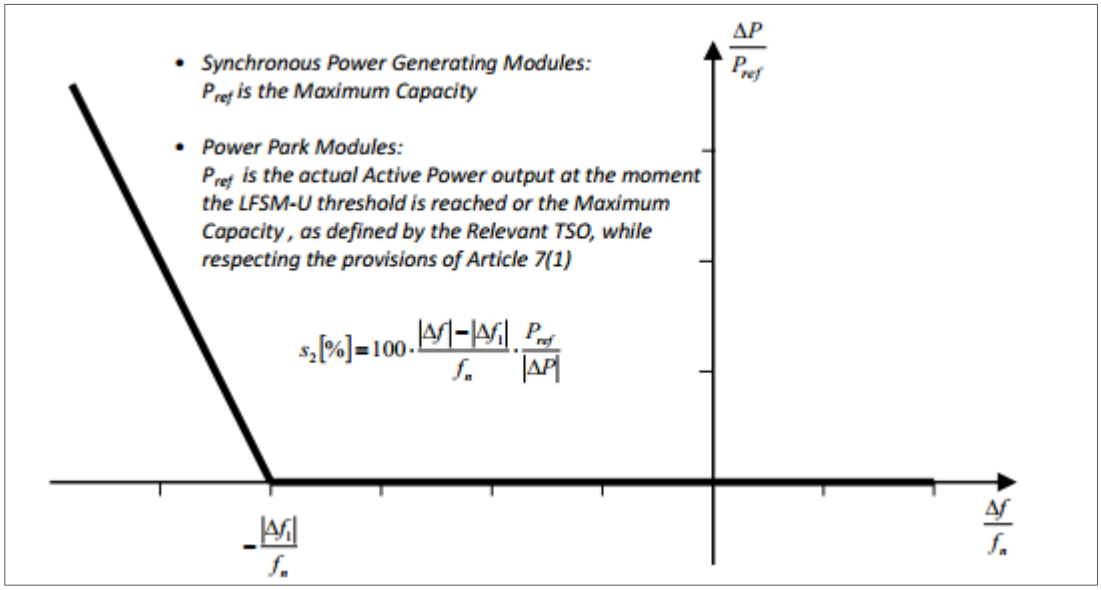

Figure 2 Active power frequency response capability of power-generating modules in LFSM-U.

c) The activation of active power frequency response by the power-generating module shall not be unduly delayed. In the event of any delay greater than two seconds, the power-generating facility owner shall justify it to the relevant TSO

d) In LFSM-U mode the power-generating module shall be capable of providing a power increase up to its maximum capacity

e) Stable operation of the power-generating module during LFSM-U operation shall be ensured

4.4 Power generating module shall be capable of maintaining constant output at its target active power values regardless of changes in frequency except where output follows the changes specified in the context of Articles 4.2, 4.5 eða greina 4.3 og 4.7 c).

4.5 Landsnet shall specify admissible active power reduction from maximum output with falling frequency in its control area as a rate of reduction falling within the boundaries, illustrated by the full lines in Figure 3: This refers to power generating modules that are unable to reach maximum power output at underfrequency due to technical issues.

a) 49 Hz: Falling by a reduction rate of 2 % of the maximum capacity at 50 Hz per 1 Hz frequency drop

b) 49.5 Hz: Falling by a reduction rate of 10 % of the maximum capacity at 50 Hz per 1 Hz frequency drop

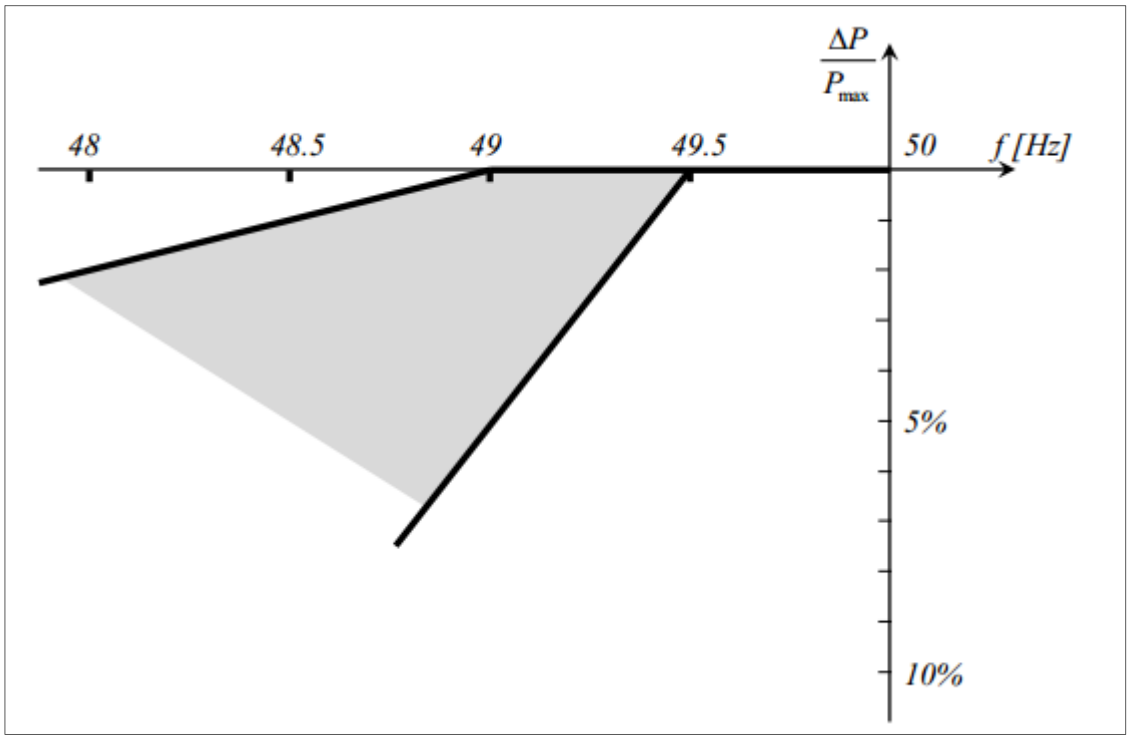

Figure 3. Maximum power capability reduction with falling frequency.

4.6 The admissible active power reduction from maximum output shall:

a) Clearly specify the ambient conditions applicable

b) Take account of the technical capabilities of power-generating modules

4.7 Power generating module of type D shall fulfil the following requirements relating to frequency stability:

a) The power-generating module control system shall becapable of adjusting an active power setpoint in line with instructions given to the power-generating facility owner

by Landsnet. The adjusted active power setpoint shall be reached without time delay. The setpoint tolerance shall be less than 0.5%

b) Manual local measures shall be allowed in cases where the automatic remote control devices are out of service

c) In addition to the points in Article 4.3, the following shall apply cumulatively when frequency sensitive mode ('FSM') is operating:

(i) The power-generating module shall be capable of providing active power frequency response in accordance with the parameters specified in Table 1 and in cooperation with Landsnet

(ii) The frequency response deadband of frequency deviation and droop must be able to be reselected

(iii) In the event of a frequency step change, the power-generating module shall be capable of activating full active power frequency response, at or above the full line shown in Figure 4 in accordance with the parameters specified by Landsnet

Table 1 Parameters for active power frequency response.

Parameters		Ranges
Active power range related to maximum capacity	$\frac{\lvert\Delta P_i\rvert}{P_{max}}$	1.5-10%
Frequency response insensitivity	$\lvert\Delta f_i\rvert$	10-30 mHz
	$\frac{\lvert\Delta f_i\rvert}{f_n}$	0.02-0,06%
Frequency response deadband		0-500m Hz
Droops		2-12%

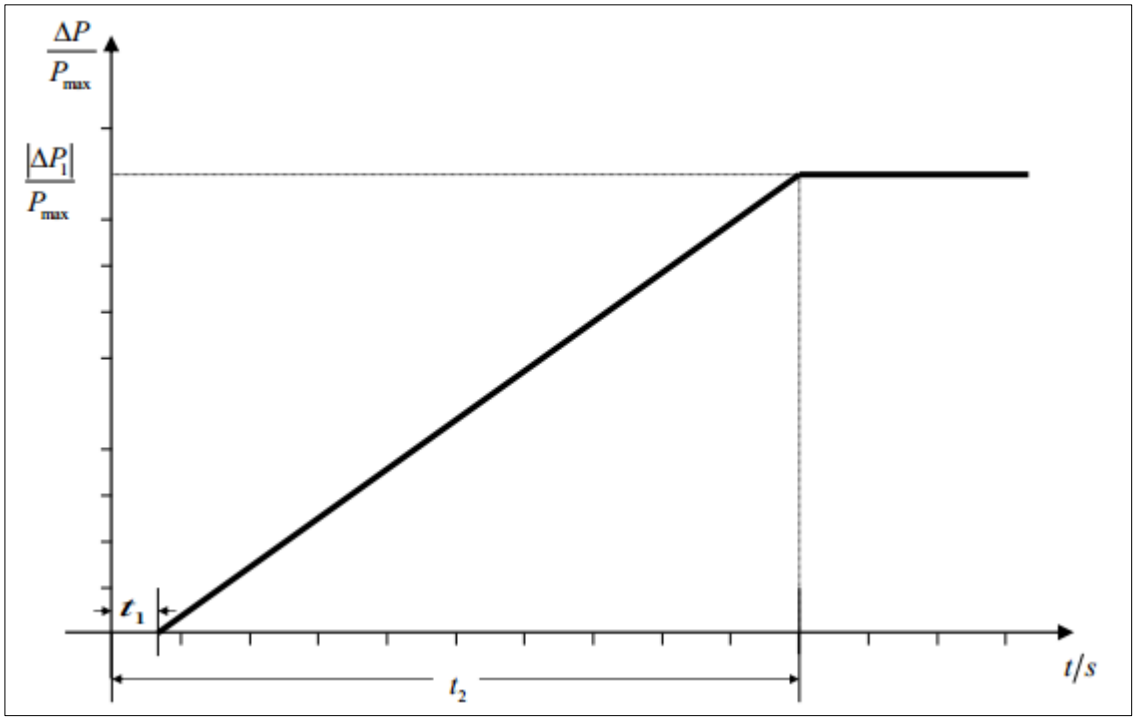

Figure 4 Active power frequency response capability.

(iv) The initial activation of active power frequency response required shall not be unduly delayed

If the delay in initial activation of active power frequency response is greater than one second, the power-generating facility owner shall provide technical evidence demonstrating why a longer time is needed

For power-generating modules without inertia, the relevant TSO may specify a shorter time than one second. If the power-generating facility owner cannot meet this requirement they shall provide technical evidence demonstrating why a longer time is needed for the initial activation of active power frequency response

(v) The power-generating module shall be capable of providing full active power frequency response for a period of 30 minutes

(vi) Within the time limits laid down in Article 4.7 c) (v), active power control must not have any adverse impact on the active power frequency response of power-generating modules

d) With regard to real-time monitoring of FSM:

(i) The communication interface shall be equipped to transfer, at least the following signals to Landsnet‘s contol centre:

- Status signal of FSM (on/off)
- Scheduled active power output

- Actual value of the active power output
- Actual parameter settings for active power frequency response
- Droop and deadband;

(ii) Landsnet shall specify additional signals to be provided by the power-generating facility by monitoring and recording devices in order to verify the performance of the active power frequency response provision of participating power-generating modules

Table 2 Parameters for full activation of active power frequency response resulting from frequency step change

Parameters		Ranges or values
Active power range related to maximum capacity (frequency response range)	$\frac{\lvert\Delta P_1\rvert}{P_{max}}$	1.5-10%
For power-generating modules with inertia, the maximum admissible initial delay t 1 unless justified otherwise		1 second
For power-generating modules without inertia, the maximum admissible initial delay t 1 unless justified otherwise in line with Article 4.7 c) (iv)		LN can specify parameters less than 1 sec
Maximum admissible choice of full activation time t 2		30 seconds

4.8 Type D power-generating modules shall fulfil the following requirements relating to voltage stability:

a) Voltage ranges:

(i) In accordance with Article 4.9- the power generating module shall be capable of staying connected to the network and operating within the ranges of the network voltage at the connection point, expressed by the voltage at the connection point related to the reference 1 pu voltage, and for the time periods specified:

- 0.90 pu-1.05 pu for an unlimited period
- 1.05 pu-1.10 pu for a period of 60 minutes

(ii) Landsnet may specify shorter periods of time during which power-generating modules shall be capable of remaining connected to the network in the event of

simultaneous overvoltage and underfrequency or simultaneous undervoltage and overfrequency

b) Wider voltage ranges or longer minimum time periods for operation may be agreed between Landsnet and the power-generating facility owner. If wider voltage ranges or longer minimum times for operation are economically and technically feasible, the power-generating facility owner shall not unreasonably withhold an agreement

c) Without prejudice to point (a), Landsnet shall have the right to specify voltages at the connection point at which a power-generating module is capable of automatic disconnection. The terms and settings for automatic disconnection shall be agreed between the relevant system operator and the power-generating facility owner

4.9 Power generating module shall be reliable and capable of fulfilling the following requirements:

a) With regard to fault-ride-through capability:

(i) Power-generating modules shall be capable of staying connected to the network and continuing to operate stably after the power system has been disturbed by secured faults. That capability shall be in accordance with a voltage-against-time profile at the connection point for fault conditions specified by Figure 5

(ii) The voltage-against-time-profile shall express a lower limit of the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault, as a function of time before, during and after the fault

(iii) The power-generating module shall be capable of remaining connected to the network and continuing to operate stably when the actual course of the phase-to-phase voltages on the network voltage level at the connection point during a symmetrical fault remain above the limit specified in Figure 5, unless the protection scheme for internal electrical faults requires the disconnection of the power-generating module from the network. The protection schemes and settings for internal electrical faults must not jeopardise fault-ride-through performance

(iv) Without prejudice to Article 4.9 (iii), undervoltage protection shall be set to the widest possible technical capability of the power-generating module, unless Landsnet requires narrower settings in accordance with Article 4.10. The settings shall be justified by the power-generating facility owner in accordance with this principle

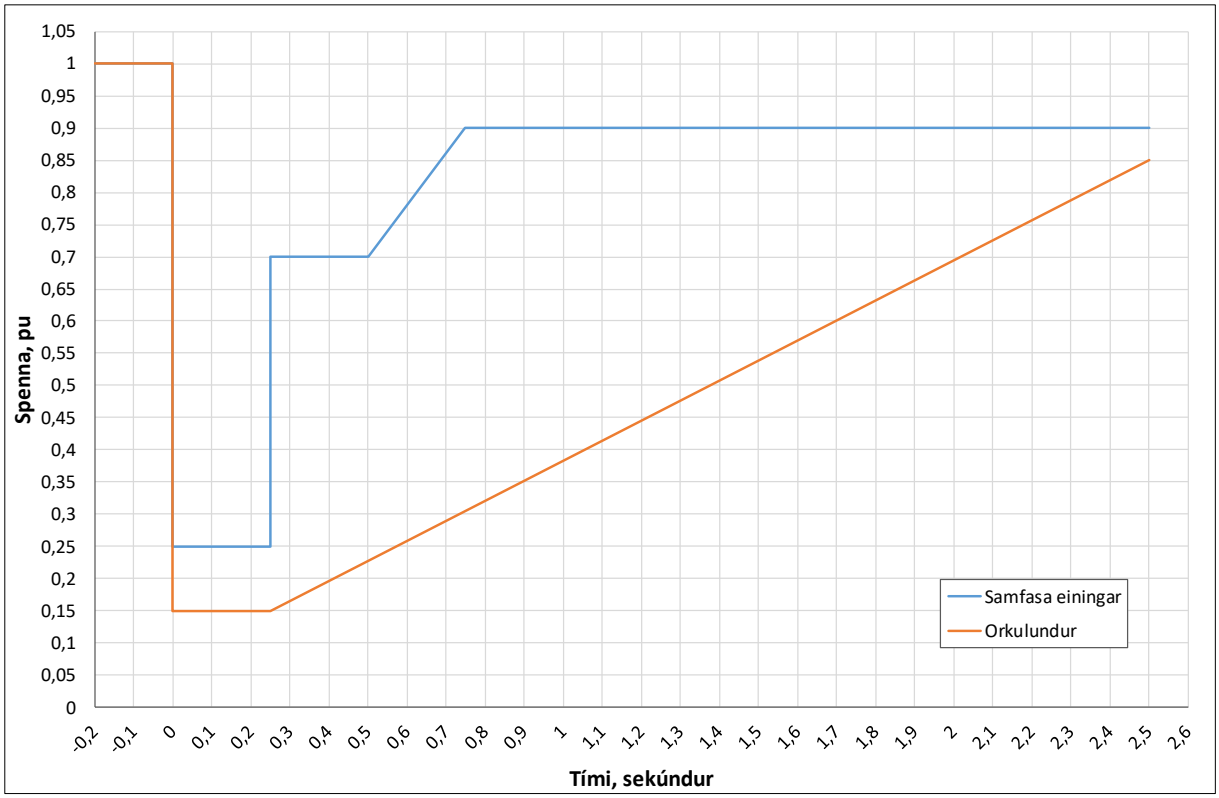

Figure 5. Fault-ride-through profile of a power-generating module. Landsnet's requirements.

Type D power generating modules shall be capable of the following:

b) In the event of power oscillations, power-generating modules shall retain steady-state stability when operating at any operating point of the P-Q-capability diagram

c) Without prejudice to Articles 4.5 and 4.6, power-generating modules shall be capable of remaining connected to the network and operating without power reduction, as long as voltage and frequency remain within the specified limits pursuant to this grid code

d) Power-generating modules shall be capable of remaining connected to the network during single-phase or three-phase auto-reclosures on meshed network lines. The details of that capability shall be subject to coordination and agreements on protection schemes and settings as referred to in Article 4.10 b)

4.10 Power-generating modules shall fulfil the following general system management requirements:

a) With regard to control schemes and settings:

(i) The schemes and settings of the different control devices of the power-generating module that are necessary for transmission system stability and for taking emergency action shall be coordinated and agreed between the relevant TSO, the relevant system operator and the power-generating facility owner

(ii) Any changes to the schemes and settings, mentioned in point 4.10 a (i), of the different control devices of the power-generating module shall be agreed upon with Landsnet

b) With regard to electrical protection schemes and settings:

(i) Landsnet's transmission system is directly grounded and Landsnet's protection system is based on that. Therefore, Landsnet requires that all equipment of customers, connected to the transmission grid, to be star-connected with a ground connected neutral on the transmission side

(ii) Landsnet shall specify the schemes and settings necessary to protect the network, taking into account the characteristics of the power-generating module. The protection schemes needed for the power-generating module and the network as well as the settings relevant to the power-generating module shall be coordinated and agreed between Landsnet and the power-generating facility owner

(iii) Electrical protection of the power-generating module shall take precedence over operational controls, taking into account the security of the system and the health and safety of staff and of the public, as well as mitigating any damage to the power-generating module

(iv) Any changes to the protection schemes and settings, mentioned in point (ii) shall be approved by Landsnet

c) Protection systems- power generating modules:

(i) The generating module shall disconnect the relevant unit from the transmission system in the event of a fault to limit any effect on the transmission system

(ii) The unit shall be disconnected from the transmission system within 100 msec in the event of a short-circuit in the power generating module

(iii) The power generating module's contribution to the short-circuit current shall be disconnected as fast as possible, within 400 ms

d) The power-generating facility owner shall organise its protection and control devices in accordance with the following priority ranking (from highest to lowest):

(i) Network and power-generating module protection

(ii) Synthetic inertia, if applicable

(iii) Frequency control (active power adjustment)

(iv) Power restriction

(v) Power gradient constraint

e) Information:

(i) Power-generating facilities shall be capable of exchanging information with Landsnet in real time and as specified by the standards used by Landsnet at any given time

(ii) Landsnet shall specify the content of information exchanges (Landsnet's signal list)

4.11 Power generating module power-generating modules shall fulfil the following requirements relating to system restoration:

a) With regard to black start capability:

(i) A power-generating module with black start capability shall be capable of starting from shutdown without any external electrical energy supply within a time frame specified by Landsnet

(ii) A power-generating module with black start capability shall be able to synchronise within the frequency limits laid down in Article 4.1 (a) and, where applicable, voltage limits specified in Article 5.2

(iii) A power-generating module with black start capability shall be capable of automatically regulating dips in voltage caused by connection of demand

(iv) A power-generating module with black start capability shall:

- Be capable of regulating load connections in block load
- Control frequency in case of overfrequency and underfrequency within the whole active power output range between minimum regulating level and maximum capacity as well as at houseload level
- Be capable of parallel operation of a few power-generating modules within one island
- Control voltage automatically during the system restoration phase

b) With regard to the capability to take part in island operation:

(i) With regard to the demands set out by Landsnet with rgeard to the capability of the power generating module to take part in island operation:

- The frequency limits for island operation shall be those established in accordance with Article 4.1 a)
- The voltage limits for island operation shall be those established in accordance with Article 4.9 and 5.2, where applicable

(ii) Power-generating modules shall be able to operate in FSM during island operation, as specified in Article 4.7 c)

In the event of a power surplus, power-generating modules shall be capable of reducing the active power output to any new operating point within the P-Q-capability diagram. The power-generating module shall be capable of reducing

active power output as much as inherently technically feasible, but to at least 55 % of its maximum capacity

(iii) The method for detecting a change from interconnected system operation to island operation shall be agreed between the power-generating facility owner and Landsnet. The agreed method of detection must not rely solely on the system operator's switchgear position signals

c) With regard to synchronisation capability:

(i) With regard to synchronisation, when starting a power-generating module, synchronisation shall be performed by the power-generating facility owner only after authorisation by Landsnet

(ii) The power-generating module shall be equipped with the necessary synchronisation facilities

(iii) Synchronisation of power-generating modules shall be possible at frequencies within the ranges set out in Article 4.1

(iv) The relevant system operator and the power-generating facility owner shall agree on the settings of synchronisation devices to be concluded prior to operation of the power-generating module. This agreement shall cover:

- Voltage
- Frequency
- Phase angle range
- Phase sequence
- Deviation of voltage and frequency

(v) In case of disconnection of the power-generating module from the network, the power-generating module shall be capable of quick re-synchronisation in line with the protection strategy agreed between the relevant system operator in coordination with Landsnet and the power-generating facility

(vi) A power-generating module with a minimum re-synchronisation time greater than 15 minutes after its disconnection from any external power supply must be designed to trip to houseload from any operating point in its P-Q-capability diagram. In this case, the identification of houseload operation must not be based solely on Landsnet‘s switchgear position signals

(vii) Power-generating modules shall be capable of continuing operation following tripping to houseload, irrespective of any auxiliary connection to the external network. The minimum operation time shall be specified by the relevant system

operator in coordination with Landsnet, taking into consideration the specific characteristics of prime mover technology

4.12 Type D power-generating modules shall fulfil the following general system management requirements :

a) With regard to loss of angular stability or loss of control, a power-generating module shall be capable of disconnecting automatically from the network. The power-generating module shall disconnect from the transmission system within 200 ms

b) Instrumentation:

(i) Power-generating facilities shall be equipped with a facility to provide fault recording and monitoring of dynamic system behaviour. This facility shall record the following parameters:

- Voltage
- Active power
- Reactive power
- Frequency

Landsnet has the right to specify quality of supply parameters to be complied with.

(ii) The settings of the fault recording equipment, including triggering criteria and the sampling rates shall be agreed between the power-generating facility owner and Landsnet.

(iv) The facilities for quality of supply and dynamic system behaviour monitoring shall include arrangements for the power-generating facility owner and Landsnet to access the information. The communications protocols for recorded data shall be agreed between the power-generating facility owner and Landsnet

c) With regard to the simulation models:

(i) At the request of Landsnet, the power-generating facility owner shall provide simulation models which properly reflect the behaviour of the power-generating module in both steady-state and dynamic simulations (50 Hz component) or in electromagnetic transient simulations. The power-generating facility owner shall ensure that the models provided have been verified against the results of compliance tests and shall notify the results of the verification to Landsnet

(ii) The models provided by the power-generating facility owner shall contain the following sub-models, depending on the existence of the individual components:

— Alternator and prime mover
— Speed and power control

— Voltage control, including, if applicable, power system stabiliser ('PSS') function and excitation control system
— Power-generating module protection models, as agreed between Landsnet and the power-generating facility owner
— Converter models for power park modules

(iii) The request by Landsnet referred to in point (i) shall include the following:

- The format in which models are to be provided
- The provision of documentation on a model's structure and block diagrams
- An estimate of the minimum and maximum short circuit capacity at the connection point, expressed in MVA, as an equivalent of the network

(iv) The power-generating facility owner shall provide Landsnet with recordings of the power-generating module's in order to compare the response of the models with actual operations

d) If Landsnet considers that it is necessary to install additional devices in a power-generating facility in order to preserve or restore system operation or security, then Landsnet and the power-generating facility owner shall investigate that matter and agree on an appropriate solution

e) Landsnet shall specify minimum and maximum limits on rates of change of active power output (ramping limits), taking into consideration the specific characteristics of prime mover technology

f) Earthing arrangement of the neutral-point at the network side of step-up transformers shall comply with the specifications set out by Landsnet

5. Requirements for synchronous power generating modules

5.1 Synchronous power generating modules shall fulfil the requirements set out in Chapter 4

5.2 Synchronous power-generating modules shall fulfil the following additional requirements relating to voltage stability:

a) With regard to reactive power capability, Landsnet shall have the right to specify the capability of a synchronous power-generating module to provide reactive power

b) With regard to the voltage control system, a synchronous power-generating module 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 power-generating module

Type D synchronous power generating module shall fulfil the following additional requirements in relation to voltage stability:

c) Landsnet may specify supplementary reactive power to be provided if the connection point of a synchronous power-generating module is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the alternator terminals

d) Power generating module shall be capable of providing reactive power at its maximum capacity within the boundaries described in Figure 6

(i) Tthe synchronous power-generating module shall be capable of moving to any operating point within its U-Q/P_{max} profile in appropriate timescales to target values requested by Landsnet

e) With regard to reactive power capability below maximum capacity, when operating at an active power output below the maximum capacity (P < Pmax), the synchronous power-generating modules shall be capable of operating at every possible operating point in the P-Q-capability diagram of the alternator of that synchronous power-generating module, at least down to minimum stable operating level. Even at reduced active power output, reactive power supply at the connection point shall correspond fully to the P-Q-capability diagram of the alternator of that synchronous power-generating module, taking the auxiliary supply power and the active and reactive power losses of the step-up transformer, if applicable, into account

f) The parameters and settings of the components of the voltage control system shall be agreed between the power-generating facility owner and Landsnet

g) The agreement referred to in subparagraph (a) shall cover the specifications and performance of an automatic voltage regulator ('AVR') with regard to steady-state voltage and transient voltage control and the specifications and performance of the excitation control system. The latter shall include:

(i) Bandwidth limitation of the output signal to ensure that the highest frequency of response cannot excite torsional oscillations on other power-generating modules connected to the network

(ii) An underexcitation limiter to prevent the AVR from reducing the alternator excitation to a level which would endanger synchronous stability

(iii) An overexcitation limiter to ensure that the alternator excitation is not limited to less than the maximum value that can be achieved whilst ensuring that the synchronous power-generating module is operating within its design limits

(iv) A stator current limiter

(v) A PSS function to attenuate power oscillations, if the synchronous power-generating module size is above a value of maximum capacity specified by the relevant TSO

5.3 Landsnet and the power-generating facility owner shall enter into an agreement regarding technical capabilities of the power-generating module to aid angular stability under fault conditions.

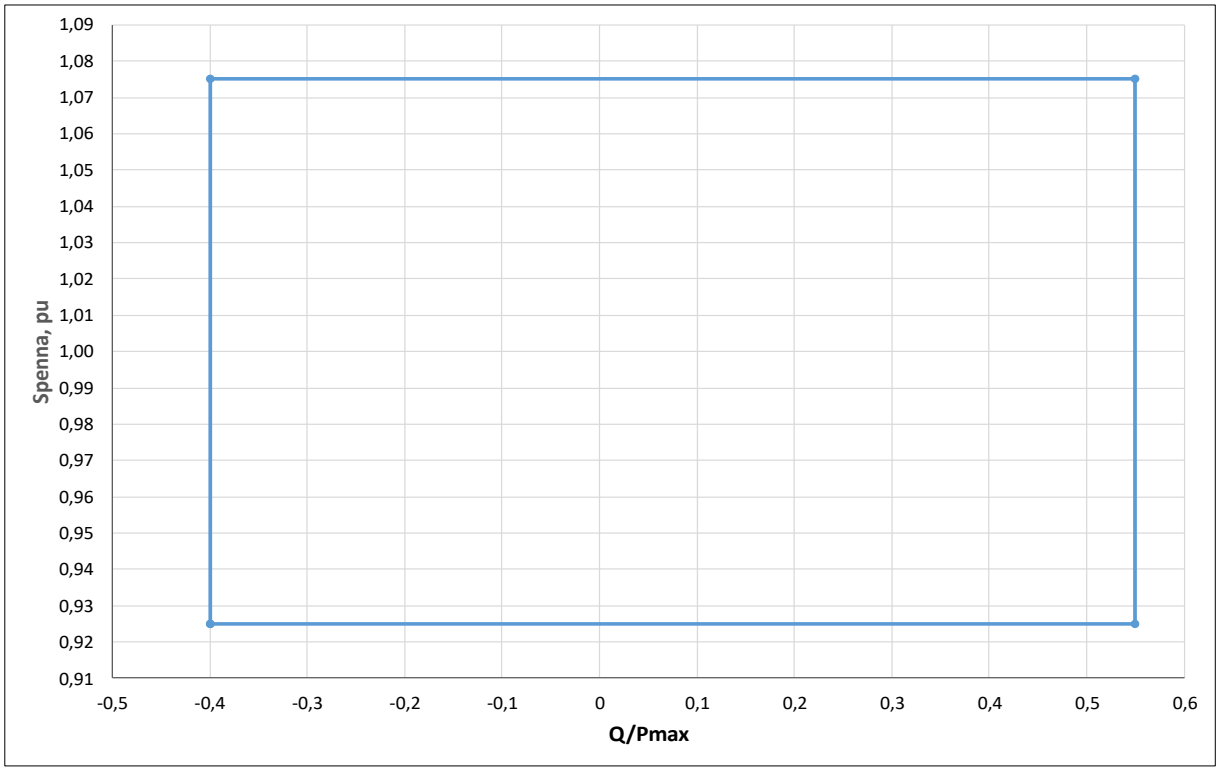

Figure 6. U-Q/Pmax-profile of a synchronous power-generating module. Power generating modules shall be capable of operating within the envelope.

6. Requirements for power park modules

6.1 Power park modules shall fulfil the requirements laid down in Chapter 4.

6.2 Power park modules shall fulfil the following additional requirements in relation to voltage stability:

a) Landsnet shall have the right to specify that power park modules be capable of providing synthetic inertia during very fast frequency deviations

b) Landsnet specifies the operating principle of control systems installed to provide synthetic inertia and the associated performance parameters

6.3 Power park modules shall fulfil the following additional requirements in relation to voltage stability:

a) Landsnet shall have the right to specify that a power park module be capable of providing fast fault current at the connection point in case of symmetrical (3-phase) faults, under the following conditions:

(i) The power park module shall be capable of activating the supply of fast fault current either by:

- Ensuring the supply of the fast fault current at the connection point, or

- Measuring voltage deviations at the terminals of the individual units of the power park module and providing a fast fault current at the terminals of these units

(ii) Landsnet shall specify the following:

- How and when a voltage deviation is to be determined as well as the end of the voltage deviation

- The characteristics of the fast fault current, including the time domain for measuring the voltage deviation and fast fault current

b) With regard to the supply of fast fault current in case of asymmetrical (1-phase or 2-phase) faults, Landsnet shall have the right to specify a requirement for asymmetrical current injection.

Power park modules of type D shall also fulfil the following requirements:

c) Landsnet may specify supplementary reactive power to be provided if the connection point of a power park module is neither located at the high-voltage terminals of the step-up transformer to the voltage level of the connection point nor at the convertor terminals, if no step-up transformer exists

d) The power park module shall be capable of providing reactive power according to Article 5.2 e) and Figure 6

e) With regard to reactive power capability below maximum capacity:

(i) The power park module shall be capable of providing reactive power at its maximum capacity within the boundaries described in Figure 7. If a power park module connects to the transmission system in a substation where a hydro power station is also connected and the hydro power station is at least twice as large as the power park module, then Landsnet can reject this requirement. This will only be allowed if there are no foreseen long term voltage problems in the area. A power park module shall be capable of providing reactive power with a power coefficient between 0.9 and 1.0, lagging or leading, at rated power- at all times

(ii) The power park module shall be capable of operating within the defined boundaries, according to Figure 8 with all units of the power park module available. If some units are unavailable due to maintenance or faults, the reactive power capability can be less, accordingly

(iii) The power park module shall be capable of moving to any operating point within its P-Q/Pmax profile in appropriate timescales to target values requested by Landsnet

f) With regard to reactive power control modes:

(i) The power park module shall be capable of providing reactive power automatically by either voltage control mode, reactive power control mode or power factor control mode in cooperation with Landsnet

(ii) For the purposes of voltage control mode, the power park module shall be capable of contributing to voltage control at the connection point by provision of reactive power exchange with the network with a setpoint voltage covering 0,95 to 1,05 pu in steps no greater than 0,01 pu, with a slope having a range of at least 2 to 7 % in steps no greater than 0.5 %. The reactive power output shall be zero when the grid voltage value at the connection point equals the voltage setpoint

(iii) The setpoint may be operated with or without a deadband selectable in a range from zero to ± 5 % of reference 1 pu network voltage in steps no greater than 0.5 %

(iv) Following a step change in voltage, the power park module shall be capable of achieving 90 % of the change in reactive power output and must settle at the value specified by the slope within a time limit of 1 sec with a steady-state reactive tolerance no greater than 5 % of the maximum reactive power

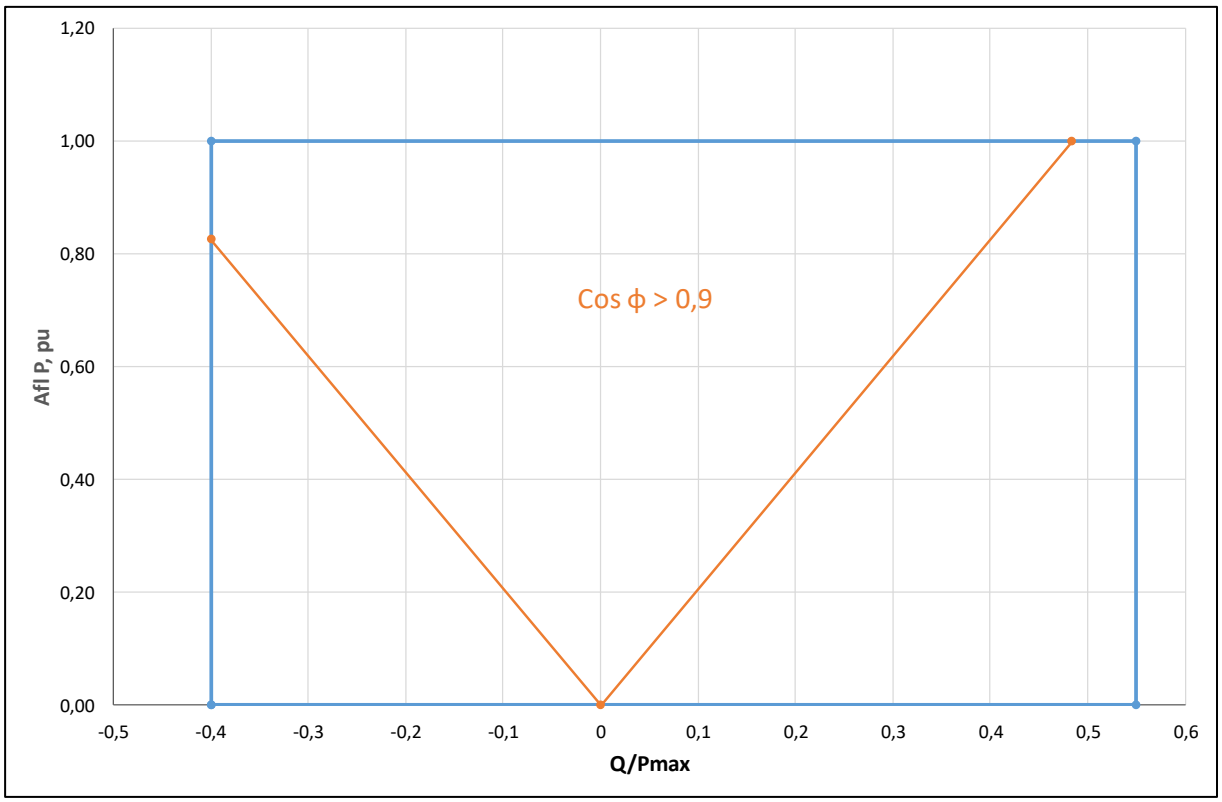

Figure 7. U-Q/Pmax-profile of a power park module. Power park modules shall be capable of operating within the envelope.

(v) For the purpose of reactive power control mode, the power park module shall be capable of setting the reactive power setpoint anywhere in the reactive power range, specified by Article 6.3 (c & d), with setting steps no greater than 5 MVAr or 5 % (whichever is smaller) of full reactive power, controlling the reactive power at the connection point to an accuracy within plus or minus 5 MVAr or plus or minus 5 % (whichever is smaller) of the full reactive power

(vi) For the purpose of power factor control mode, the power park module shall be capable of controlling the power factor at the connection point within the required reactive power range stated in Article 6.3 (c & d), with a target power factor in steps no greater than 0,01. Landsnet shall specify the target power factor value, its tolerance and the period of time to achieve the target power factor following a sudden change of active power output

(vii) Landsnet, in coordination with the power park module owner, shall specify which reactive power control mode options and associated setpoints apply, and what further equipment is needed to make the adjustment of the relevant setpoint operable remotely

g) Landsnet shall specify whether active power contribution or reactive power contribution has priority during faults for which fault-ride-through capability is required. If priority is given to active power contribution, this provision has to be established no later than 150 ms from the fault inception

h) A power park module shall be capable of contributing to damping power oscillations at Landsnet‘s request. The voltage and reactive power control characteristics of power park modules must not adversely affect the damping of power oscillations

6.4 Type D power park modules shall fulfil the following additional requirements in relation to robustness:

a) Landsnet shall specify the post-fault active power recovery that the power park module is capable of providing and shall specify:

(i) When the post-fault active power recovery begins, based on a voltage criterion

(ii) A maximum allowed time for active power recovery

(iii) A magnitude and accuracy for active power recovery

b) The specifications shall be in accordance with the following principles:

(i) Interdependency between fast fault current requirements according to Article 6.3 a) and b) and active power recovery

(ii) Dependence between active power recovery times and duration of voltage deviations

(iii) A specified limit of the maximum allowed time for active power recovery

(iv) Adequacy between the level of voltage recovery and the minimum magnitude for active power recovery

(v) Adequate damping of active power oscillations

7. Confirming power plant specifications

7.1 When preparing and designing a power plant considerations shall be given to its effects on the electricity system, not only during normal operation but also during disturbances. In this respect the power plants effects on the system's dynamic behaviour during operational disturbances shall be simulated. The producer shall provide Landsnet with a precise model of the particular power plant and it’s connection to the transmission system, in keeping with the details of Landsnet requests.

7.2 Landsnet may take part in the plant's first tests and also to conduct later tests in order to test whether the requirements in these Terms have been fulfilled in regard to power plant specifications.

8. Liability

8.1 The stipulations on liability in the General Terms on Electricity Transmission and System Management (A1) shall also apply to the technical requirements for production units.

9. Force Majeure

9.1 The stipulations on force majeure in the General Terms on Electricity Transmission and System Management (A1) shall also apply to the technical requirements for production units..

10. Breach of terms

10.1 1 In the event of breaches of these Terms, the National Energy Authority may be requested to take action on the basis of Chapter VII of the Electricity Act.

11. Regulation and remedies

11.1 The National Energy Authority shall regulate the operation of companies pursuant to the Electricity Act, No. 65/2003, and their compliance with the conditions applying to these operations according to laws, regulations and these Terms.

11.2 In case of disagreement on the implementation or interpretation of provisions in these terms, the National Energy Authority shall be asked for a resolution in instances where it has the power to make a ruling on the basis of Chapter VII of the Electricity Act, and the Appeals Committee on Electricity asked when applicable. If a dispute cannot be appealed to the National Energy Authority, the case may be referred to the District Court of Reykjavik for resolution.

12. References

12.1 A.1 General Terms on Electricity Transmission and System Management.

12.2 Overview of requirements for various power generating module types.

Reference 12.2

Overview of requirements for various power generating module types

	Landsnet (references 2.29 & 2.30)		B	D
4.	**General requirements: power generating modules**			
	4.1		x	x
	4.2		x	x
	4.3			x
	4.4		x	x
	4.5		x	x
	4.6		x	x
	4.7			x
	4.8			x
	4.9	a)	x	x
		b) - d)		x
	4.10		x	x
	4.11		x	x
	4.12			x
5.	**Requirements for synchronised power generating**			
	5.1		x	x
	5.2	a) - b)	x	x
		c) - g)		x
	5.3			x
6.	**Requirements for power parks**			
	6.1		x	x
	6.2		x	x
	6.3	a) - c)	x	x
		d) - h)		x
	6.4			x

Chapters not referred to in the table above cover all power generating modules.