Bilag 2: Kravdokument – RfG v1

Dok. ansvarlig: JVI
Sekretær:
Sagsnr.: s2023-670
Doknr: d2023-24841-2.0
07-08-2023

Krav fastsat i henhold til EU-Forordning 2016/631 – Requirements for grid connection of generators (RfG)

Ændring	Version	Dato for godkendelse	Dato
Krav godkendt af Forsyningstilsynet i forbindelse med gennemførelse af EU-Forordning 2016/631 inkl. ændringer iht. FSTS' høring	0.1	22/02-2019	07/03-2023
Ændringer af krav med hjemmel i EU-forordning 2016/631 anmeldt til Forsyningstilsynet.	1		21/03-2023

Normativt krav – behandles ikke
Krav fastsat af Dx
Krav fastsat af Tx
Krav fastsat i samarbejde mellem Dx og Tx

Art. nr.	Art. stk.	Art. afsn.	Art. enh.	Artikel emne	Krav	Revision
General requirements for type A power-generating modules						
13	1			Type A power generating modules shall fulfil the following requirements relating to frequency stability:	-	
13	1	a		With regard to frequency ranges:	-	

13	1	a	i	a power generating module shall be capable of remaining connected to the network and operate within the frequency ranges and time periods specified in Table 2;	Tabel 2 CE: 47,5 – 48,5 Hz: 30 min 48,5 – 49,0 Hz: 30 min N: 48,5 – 49,0 Hz: 30 min Teknisk præciserende tekst: Det betyder, minimum 30 minutter i frekvensområdet 48,5 Hz til 49,0 Hz samt 30 minutter i frekvensområdet 47,5 Hz til 48,5 Hz. Den samlede drift under 49 Hz kan dog ikke overstige 60 minutter.	
13	1	a	ii	the relevant system operator, in coordination with the relevant TSO, 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 module, if it is required to preserve or to restore system security;	Transmissionssystem: ej relevant Distributionssystem: ej relevant	
13	1	a	iii	the power generating facility owner shall not unreasonably withhold consent to apply wider frequency ranges or longer minimum times for operation, takin account of their economic and technical feasibility.	-	
13	1	b		With regard to the rate of change of frequency withstand capability, a power-generating module shall be capable of staying connected to the network and operate at rates of change of frequency up to a value specified by the relevant TSO, unless disconnection was triggered by rate-ofchange-of-frequency-type loss of mains protection. The relevant system operator, in coordination with the relevant TSO, shall specify this rate-of-change-of-frequency-type loss of mains protection. Table 2 Minimum time periods for which a power-generating module	RoCoF: 2,0 Hz/s RoCoF er betegnelsen for frekvensændringen som funktion af tiden. Frekvensændringen, RoCoF, beregnes efter nedenstående eller ækvivalent princip.	

				has to be capable of operating on different frequencies, deviating from a nominal value, without disconnecting from the network.	Frekvensmålingen anvendt til beregning af frekvensændringen er baseret på en 200 ms måleperiode, hvor middelværdien beregnes. Frekvensmålingerne skal foregå løbende så der beregnes en ny værdi for hver 20 ms. RoCoF [Hz/s] skal beregnes som forskellen mellem den netop udførte middelværdifrekvensberegning og den middelværdi frekvensberegning der blev foretaget for 20 ms siden. (df/dt = (middelværdi 2 – middelværdi 1)/0,020 [Hz/s]) LOM detektering: SPGM/PPM/Type A, B, C og D Der anvendes RoCoF i distributionsnettet, middelværdi/måling beregnes som beskrevet i forbindelse med RoCoF robusthed RoCoF – Udkobling overfrekvens: hvor beregnet RoCoF værdi er > +2,5 Hz/s i mere end i 120 ms RoCoF – Udkobling underfrekvens: hvor beregnet RoCoF værdi er > -2,5 Hz/s i mere end i 120 ms Underspændingstrin 2 kan anvendes for A anlæg som alternativ til RoCoF. Underspænding (trin 2): Uc < 0,8 pu i 200ms	
13	2			With regard to the limited frequency sensitive mode — overfrequency (LFSM-O), the following shall apply, as determined by the relevant TSO for its control area in coordination with the TSOs of the same synchronous area to ensure minimal impacts on neighbouring areas:	-	

13	2	a		the power generating module shall be capable of activating the provision of active power frequency response according to figure 1 at a frequency threshold and droop settings specified by the relevant TSO;	a) vælges Pn anvendes som Pref for elproducerende produktionsanlæg Frekvensparametrene i reguleringsfunktionerne for aktiv effekt skal kunne indstilles med en opløsning på 10 mHz eller bedre. - Reguleringsstatikkerne skal kunne indstilles med en opløsning på 1 % eller bedre. - For reguleringsfunktionen for frekvensrespons for overfrekvens gælder, at nøjagtigheden for en fuldført eller en kontinuerlig regulering, maksimalt må afvige med en gennemsnitlig størrelse på fejlen < 5 % af Pn målt over en periode på 1 minut. - Frekvensmålinger skal udføres med en nøjagtighed på ± 10 mHz eller bedre. Teknisk præciserende tekst: Ved LFSM-O tilstand skal anlæggets aktive effekt følge den krævede statik, når netfrekvensen er større end den specificerede grænseværdi, knækfrekvens, for LFSM-O, uanset om netfrekvensen er stigende eller faldende.	
13	2	b		instead of the capability referred to in paragraph (a), the relevant TSO may choose to allow within its control area automatic disconnection and reconnection of power generating modules of Type A at randomised frequencies, ideally uniformly distributed, above a frequency threshold, as determined by the relevant TSO where it is able to demonstrate to the relevant regulatory authority, and with the	b) vælges ikke.	

				cooperation of power generating modulefacility owners, that this has a limited cross-border impact and maintains the same level of operational security in all system states;		
13	2	c		the frequency threshold shall be between 50.2 Hz and 50.5 Hz inclusive;	CE: 50,2 Hz N: 50,5 Hz	
13	2	d		the droop settings shall be between 2 % and 12 %;	CE: Synkrone produktionsanlæg: 5 % Elproducerende produktionsanlæg: 5 % N: Synkrone produktionsanlæg: 4 % Elproducerende produktionsanlæg: 4 %	
13	2	e		the power generating module shall be capable of activating a power frequency response with an initial delay that is as short as possible. If that delay is greater than two seconds, the power generating facility owner shall justify the delay, providing technical evidence to the relevant TSO;	-	
13	2	f		the relevant TSO may require that upon reaching minimum regulating level, the power generating module be capable of either:	-	
13	2	f	i	continuing operation at this level; or	i) vælges.	
13	2	f	ii	Further decreasing active power output;	ii) vælges ikke.	
13	2	g		the power generating module shall be capable of operating stably during LFSM-O operation. When LFSM-O is active, the LFSM-O setpoint will prevail over any other active power setpoints.	-	
13	3			The power generating module shall be capable of maintaining constant output at its target active power value regardless of changes in frequency, except where output follows the changes specified in the context of paragraphs 2 and 4 of this Article or points (c) and (d) of Article 15(2) as applicable.		

13	4			The relevant TSO 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 2:	6% af Pn per Hz, start ved 49,0 Hz.	
13	4	a		below 49 Hz falling by a reduction rate of 2 % of the maximum capacity at 50 Hz per 1 Hz frequency drop;	-	
13	4	b		below 49.5 Hz falling by a reduction rate of 10 % of the maximum capacity at 50 Hz per 1 Hz frequency drop	-	
13	5			The admissible active power reduction from maximum output shall:	-	
13	5	a		clearly specify the ambient conditions applicable;	Under normale driftsforhold og efter bedste evne i forhold til det aktuelle driftspunkt samt ved omgivelseskonditioner som jf. anlægsproducentens tydelige anlægsspecifikationer er bekendtgjort for anlægsejer samt valideret i form af relevant produktionsanlægsperformancetest.	
13	5	b		take account of the technical capabilities of power generating modules		
13	6			The power generating module shall be equipped with a logic interface (input port) in order to cease active power output within five seconds following an instruction being received at the input port. The relevant system operator shall have the right to specify requirements for equipment to make this facility operable remotely.	Det aftales med elforsyningsvirksomheden, om anlægget skal kunne fjernstyres.	
13	7			The relevant TSO shall specify the conditions under which a power generating module is capable of connecting automatically to the network. Those conditions shall include:		
13	7	a		frequency ranges within which an automatic connection is admissible, and a corresponding delay time; and	DK1: 47,5 – 50,2 Hz DK2: 47,5 – 50,5 Hz	

					Automatisk indkobling af et anlæg må tidligst finde sted tre minutter efter, at spændingen er inden for den normale driftsspænding og frekvensen er inden for de specificerede områder. Synkronisering mellem anlæg og det kollektive elforsyningsnet skal foregå automatisk.	
13	7	b		(b) maximum admissible gradient of increase in active power output. Automatic connection is allowed unless specified otherwise by the relevant system operator in coordination with the relevant TSO.	20% Pn/min	
General requirements for type B power-generating modules						
14	1			Type B power generating modules shall fulfil the requirements set out in Article 13, except for Article 13(2)(b).	-	
14	2			Type B power generating modules shall fulfil the following requirements in relation to frequency stability:	-	
14	2	a		to control active power output, the power generating module shall be equipped with an interface (input port) in order to be able to reduce active power output following an instruction at the input port; and	-	
14	2	b		the relevant system operator shall have the right to specify the requirements for further equipment to allow active power output to be remotely operated.	Fjernstyring af aktiv effekt skal implementeres for produktionsanlæg på 1 MW (B2 anlæg) eller derover.	
14	3			Type B power generating modules shall fulfil the following requirements in relation to robustness:	-	
14	3	a		with regard to fault-ride-through capability of power generating modules:	-	
14	3	a	i	each TSO shall specify a voltage-against-time-profile in line with Figure 3 at the connection point for fault conditions, which describes the conditions in which the power generating module is capable of staying connected to the network and continuing to operate stably after the	Krav jf. Energinets bilag 1.C CE/N – PPM - #1 – A14(3)(a) Spænding (pu) | Tid [sekunder]	

				power system has been disturbed by secured faults on the transmission system;	<table><tr><td>U_{ret}:</td><td>0,15</td><td>t_{clear}:</td><td>0,25</td></tr><tr><td>U_{clear}:</td><td>0,15</td><td>t_{rec1}:</td><td>0,25</td></tr><tr><td>U_{rec1}:</td><td>0,15</td><td>t_{rec2}:</td><td>0,25</td></tr><tr><td>U_{rec2}:</td><td>0,9</td><td>t_{rec3}:</td><td>1,5</td></tr></table> <table><tr><td colspan="4">CE/N – SPGM - #2 – A14(3)(a)</td></tr><tr><td colspan="2">Spænding (pu)</td><td colspan="2">Tid [sekunder]</td></tr><tr><td>U_{ret}:</td><td>0,3</td><td>t_{clear}:</td><td>0,25</td></tr><tr><td>U_{clear}:</td><td>0,7</td><td>t_{rec1}:</td><td>0,25</td></tr><tr><td>U_{rec1}:</td><td>0,7</td><td>t_{rec2}:</td><td>0,7</td></tr><tr><td>U_{rec2}:</td><td>0,9</td><td>t_{rec3}:</td><td>1,5</td></tr></table>	
14	3	a	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;	Jf. A14(3)(a)(i)	
14	3	a	iii	the lower limit referred to in point (ii) shall be specified by the relevant TSO using the parameters set out in Figure 3, and within the ranges set out in Tables 3.1 and 3.2;	Jf. A14(3)(a)(i)	
14	3	a	iv	each TSO shall specify and make publicly available the pre-fault and post-fault conditions for the fault-ride-through capability in terms of: – the calculation of the pre-fault minimum short circuit capacity at the connection point; – pre-fault active and reactive power operating point of the power generating module at the connection point and voltage at the connection point; and – calculation of the post-fault minimum short circuit capacity at the connection point.	Kortslutningskatalog fastlægger metode for beregning af kortslutningseffekt samt beregner konditioner i kendte tilslutningspunkter Anlægskonditioner: Anlægsegenskaber er specificeret ved Pn og PF = 1	
14	3	a	v	at the request of a power generating facility owner, the relevant system operator shall provide the pre-fault and post-fault conditions to be considered for fault-ride-through capability as an outcome of the calculations at the connection point as specified in point (iv)	Fastlagt beregningsmetode anvendes	

				regarding: – pre-fault minimum short circuit capacity at each connection point expressed in MVA; – pre-fault operating point of the power generating module expressed in active power output and reactive power output at the connection point and voltage at the connection point; and – post-fault minimum short circuit capacity at each connection point expressed in MVA. Alternatively, the relevant system operator may provide generic values derived from typical cases;		
14	3	a	vi	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, given the pre-fault and post-fault conditions in points (iv) and (v) of paragraph (3)(a), remain above the lower limit specified in point (ii) of paragraph (3)(a), 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;	-	
14	3	a	vii	without prejudice to point (vi) of paragraph (3)(a), undervoltage protection (either fault-ride- through capability or minimum voltage specified at the connection point voltage) shall be set by the power generating facility owner according to the widest possible technical capability of the power generating module, unless the relevant system operator requires narrower settings in accordance with point (b) of paragraph (5). The settings shall be justified by the power generating facility owner in accordance with this principle;	-	
14	3	b		Fault-ride-through capabilities in case of asymmetrical faults shall be specified by each TSO.	FRT krav er gældende for symmetriske såvel som asymmetriske fejl.	
14	4			Type B power generating modules shall fulfil the following requirements relating to system restoration:	-	

14	4	a		the relevant TSO shall specify the conditions under which a power generating module is capable of reconnecting to the network after an incidental disconnection caused by a network disturbance; and	DK1: 47,5 – 50,2 Hz DK2: 47,5 – 50,5 Hz I spændingsområdet for ubegrænset driftstid. Genindkobling efter 3 min. Gradient: 20 % Pn/min Kobling med eget udstyr er tilladt så længe nettet er spændingssat. Kobling med andres udstyr er efter aftale med anlægsejer.	
14	4	b		installation of automatic reconnection systems shall be subject both to prior authorisation by the relevant system operator and to the reconnection conditions specified by the relevant TSO.	Jf. A14(4)(a)	
14	5			Type B power generating modules shall fulfil the following general system management requirements:	-	
14	5	a		with regard to control schemes and settings:	-	
14	5	a	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;	Systemværn: Systemoperatøren – i samarbejde med den systemansvarlige virksomhed - skal oplyse, om der er krav til etablering af et systemværn i forbindelse med fastlæggelse af POC. Absolut effektbegrænser: Absolut effektbegrænser bruges til at beskytte det kollektive elforsyningsnet mod overbelastning i kritiske situationer. Angivelse af setpunkter skal kunne ske i trin på 1% af Pn eller bedre.	

					Reguleringen skal ske med en nøjagtighed på ±2 % af nominel aktiv effekt for produktionsanlægget. Nøjagtigheden for reguleringen måles over en periode på 1 minut. Reguleringen med en ny parameter for absolut-effektbegrænser skal være fuldført inden for 5 minutter fra modtagelse af ordre om parameterændring. Medmindre anden funktionalitet, inklusive markedsydelser, kræver en højere gradient fx genoprettelse af aktiv effekt efter fejl m.m., må gradienten ikke overstige mere end 20 % af Pn/min. Det gælder både for op- og nedregulering under hensyntagen til tilgængeligheden af den primære energikilde.	
14	5	a	ii	any changes to the schemes and settings, mentioned in point (i), of the different control devices of the power generating module shall be coordinated and agreed between the relevant TSO, the relevant system operator and the power generating facility owner, in particular if they apply in the circumstances referred to in point (i) of paragraph (5) (a);	-	
14	5	b		with regard to electrical protection schemes and settings:	-	
14	5	b	i	the relevant system operator 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 the relevant system operator and the power generating facility owner. The protection schemes and settings for internal electrical faults must not jeopardise the performance of a power generating module, in line with the requirements set out in this Regulation;	Relæbeskyttelsen skal ved interne kortslutninger i anlægget være selektiv med netbeskyttelsen. Anlæg skal udkobles eller stoppes, hvis et målesignal afviger mere fra dets nominelle værdi end indstillingen. Nøjagtigheden, hvormed spænding og frekvens måles, skal være henholdsvis ±1 % af U_n og ±0,05 Hz eller bedre.	

Hvis et anlæg isoleres med en del af det kollektive elforsyningsnet, må anlægget ikke give anledning til midlertidige overspændinger, der kan medføre skader på anlægget eller det kollektive elforsyningsnet.

Beskyttelses funktioner:

Beskyttelses-funktion	Indstilling (Interval/opløsning)	Funktionstid (interval/opløsning)
Overspænding (trin 2)	1,0 – 1,3 U / 0,01 Standard: 1,15 U	0,1 – 5 s / 0,05 Standard: 0,2 s
Overspænding (trin 1)	1,0 – 1,2 U / 0,01 Standard: 1,10 U	0,1 – 100 s / 0,1 Standard: 60 s
Underspænding (trin 1)	0,2 – 1,0 U / 0,01 Standard: 0,85 U	0,1 – 100 s / 0,1 Standard: 50 s
Overfrekvens	50,0 – 52,0 Hz / 0,1 Standard: 51,5 Hz	0,1 – 5 s / 0,05 Standard: 0,2 s
Underfrekvens	47,0 – 50,0 Hz / 0,1 Standard: 47,5 Hz	0,1 – 5 s / 0,05 Standard 0,2 s

For produktionsanlæg tilsluttet lavspændingsnettet (≤1 kV) er U lig med Un som er den nominelle spænding i lavspændingsnettet (400 V).
For produktionsanlæg tilsluttet mellem- og højspændingsnettet (< 1 kV) er U lig med Uc som er den normale driftsspænding i tilslutningspunktet

Yderligere krav for synkrone produktionsanlæg:

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>
<table>
<tr><td>Beskyttelses-funktion</td><td>Indstilling</td><td>Funktionstid</td></tr>
<tr><td>Synkron underspænding*</td><td>Fastsættes af elforsynings-virksomheden</td><td>≤ 50 ms</td></tr>
<tr><td>Overstrøm (trin 2)**</td><td>Fastsættes af elforsynings-virksomheden</td><td>50 ms</td></tr>
<tr><td>Overstrøm (trin 1)</td><td>1,2 I_n</td><td>2 s</td></tr>
<tr><td colspan="3">* Kun krav hvis elforsyningsvirksomheden vurderer, at der er risiko for asynkron sammenkobling
** Hvis der ikke anvendes synkront underspændingsrelæ, anvendes generatorfabrikantens indstillinger for overstrømsbeskyttelse</td></tr>
</table>

Det er tilladt at benytte en sikring i stedet for overstrøm (trin 1). I så fald skal sikringens størrelse og karakteristik godkendes af elforsyningsvirksomheden.
</td><td></td></tr>
<tr><td>14</td><td>5</td><td>b</td><td>ii</td><td>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;</td><td>-</td><td></td></tr>
<tr><td>14</td><td>5</td><td>b</td><td>iii</td><td>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;</td><td>Jf. A14(5)(b)(i)</td><td></td></tr>
</table>

				– inter-area oscillations; – inrush current; – asynchronous operation (pole slip); – protection against inadmissible shaft torsions (for example, subsynchronous resonance); – power generating module line protection; – unit transformer protection; – backup against protection and switchgear malfunction; – overfluxing (U/f); – inverse power; – rate of change of frequency; and – neutral voltage displacement.		
14	5	b	iv	changes to the protection schemes needed for the power generating module and the network and to the settings relevant to the power generating module shall be agreed between the system operator and the power generating facility owner, and agreement shall be reached before any changes are made;	-	
14	5	c		the power generating facility owner shall organise its protection and control devices in accordance with the following priority ranking (from highest to lowest):	-	
14	5	c	i	network and power generating module protection;	-	
14	5	c	ii	synthetic inertia, if applicable;	-	
14	5	c	iii	frequency control (active power adjustment);	-	
14	5	c	iv	power restriction; and	-	
14	5	c	v	power gradient constraint.	-	
14	5	d		with regard to information exchange:	-	
14	5	d	i	power generating facilities shall be capable of exchanging information with the relevant system operator or the relevant TSO in real time or	Informationsudveksling: realtid eller periodisk – med tidsstempling.	

				periodically with time stamping, as specified by the relevant system operator or the relevant TSO;	Maksimal opdateringstid af funktionsstatus (aktiveret/de-aktiveret) er 10 ms. Maksimal opdateringstid af parameterværdi er 1 sekund. Maksimal opdateringsværdi af måleværdier er 1 sekund. Øvrige krav specificeres under A14(5)(d)(ii)	
14	5	d	ii	the relevant system operator, in coordination with the relevant TSO, shall specify the content of information exchanges including a precise list of data to be provided by the power generating facility.	Krav jf. Energinets Bilag 1.A	
General requirements for type C power-generating modules						
15	1			Type C power generating modules shall fulfil the requirements laid down in Articles 13 and 14, except for Article 13(2)(b) and (6) and Article14(2).	-	
15	2			Type C power generating modules shall fulfil the following requirements relating to frequency stability:	-	
15	2	a		with regard to active power controllability and control range, the power generating module control system shall be capable of adjusting an active power setpoint in line with instructions given to the power generating facility owner by the relevant system operator or the relevant TSO. The relevant system operator or the relevant TSO shall establish the period within which the adjusted active power setpoint must be reached. The relevant TSO shall specify a tolerance (subject to the availability of the prime mover resource) applying to the new setpoint and the time within which it must be reached;	Synkrone produktionsanlæg: Minimum 1 % af Pn /min, desuden 10 minutters reaktionstid til teknologineutralitet hvis nødvendigt. Elproducerende produktionsanlæg: Minimum 20 % af Pn /min. Angivelse af setpunkter for aktiv effekt skal kunne ske med en opløsning på 1 % af Pn eller bedre. Frekvensparametrene i reguleringsfunktionerne for aktiv effekt skal kunne indstilles med en opløsning på 10 mHz eller bedre.	

					Reguleringsstatikkerne skal kunne indstilles med en opløsning på 1 % eller bedre af Pn. For alle reguleringsfunktioner for aktiv effekt gælder, at nøjagtigheden for en fuldført eller en kontinuerlig regulering, maksimalt må afvige med en gennemsnitlig størrelse på fejlen på 2 % af Pn målt over en periode på 1 minut. (gælder dog ikke for LFSM-O og LFSMU) Frekvensmålinger skal udføres med en nøjagtighed på ± 10 mHz eller bedre.	
15	2	b		manual, local measures shall be allowed in cases where the automatic remote control devices are out of service. The relevant system operator or the relevant TSO shall notify the regulatory authority of the time required to reach the setpoint together with the tolerance for the active power;	Jf. A15(2)(a)	
15	2	c		n addition to paragraph 2 of Article 13(2), the following requirements shall apply to type C power generating modules with regard to limited frequency sensitive mode – underfrequency (LFSM-U):	-	
15	2	c	i	the power generating module shall be capable of activating the provision of active power frequency response at a frequency threshold and with a droop specified by the relevant TSO in coordination with the TSOs of the same synchronous area as follows: – the frequency threshold specified by the TSO shall be between 49.8 Hz and 49.5 Hz inclusive; – the droop settings specified by the TSO shall be in the range 2 – 12 %. This is represented graphically in Figure 4;	CE: 49,8 Hz Droop range: 2 – 12 %. Droop: 5 % N: 49.5 Hz Droop range: 2 – 12 %. Droop: 4 %	

					Frekvensmålinger skal udføres med en nøjagtighed på ± 10 mHz eller bedre. Reguleringsfunktionens følsomhed skal være ± 10 mHz eller bedre.	
15	2	c	ii	the actual delivery of active power frequency response in LFSM-U mode shall take into account: – ambient conditions when the response is to be triggered; – the operating conditions of the power generating module, in particular limitations on operation near maximum capacity at low frequencies and the respective impact of ambient conditions according to paragraphs 4 and 5 of Article 13; and – the availability of the primary energy sources.	-	
15	2	c	iii	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;	-	
15	2	c	iv	in LFSM-U mode the power generating module shall be capable of providing a power increase up to its maximum capacity;	-	
15	2	c	v	stable operation of the power generating module during LFSM-U operation shall be ensured; Figure 4: active power frequency response capability of power generating modules in LFSM-U. Pref is the reference active power to which DP is related and may be specified differently for synchronous power generating modules and power park modules. DP is the change in active power output from the power generating module. fn is the nominal frequency (50 Hz) in the network and Df is the frequency deviation in the network. At underfrequencies where Df is below Df1 the power generating module has to provide a positive active power output change according to the droop S2.	Pn anvendes som Pref for både synkrone og elproducerende produktionsanlæg.	
15	2	d		in addition to point (c) of paragraph (2), the following shall apply cumulatively when frequency sensitive mode ('FSM') is operating:	-	

15	2	d	i	the power generating module shall be capable of providing active power frequency response in accordance with the parameters specified by each relevant TSO within the ranges shown in Table 4. In specifying those parameters, the relevant TSO shall take account of the following facts: – in case of overfrequency, the active power frequency response is limited by the minimum regulating level; – in case of underfrequency, the active power frequency response is limited by maximum capacity; – the actual delivery of active power frequency response depends on the operating and ambient conditions of the power generating module when this response is triggered, in particular limitations on operation near maximum capacity at low frequencies according to paragraphs 4 and 5 of Article 13 and available primary energy sources; Parameters Ranges Active power range related to maximum capacity 1.5 – 10 % Frequency response insensitivity 10 – 30 mHz 0.02 – 0.06 % Frequency response deadband 0 – 500 mHz Droop 2 – 12 % Table 4: Parameters for active power frequency response in FSM (explanation for Figure 5) Figure 5: Active power frequency response capability of power generating modules in FSM illustrating the case of zero deadband and insensitivity. Pref is the reference active power to which DP is related. DP is the change in active power output from the power generating module. fn is the nominal frequency (50 Hz) in the network and Df is the frequency deviation in the network.	CE: Interval for aktiv effect: 1,5 – 10 % (minimum krav) FRI: 10 mHz FRD: 0 – 200 mHz Droop: 2 – 12 % Pn anvendes som Pref for både synkrone og elproducerende produktionsanlæg. N: Interval for aktiv effekt: 1,5 – 10 % (minimum krav) FRI: 10 mHz FRD: 0 – 500 mHz Droop: 2 – 12 % Pn anvendes som Pref for både synkrone og elproducerende produktionsanlæg.	
15	2	d	ii	the frequency response deadband of frequency deviation and droop must be able to be reselected repeatedly;	-	

15	2	d	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 6 in accordance with the parameters specified by each TSO (which shall aim at avoiding active power oscillations for the power generating module) within the ranges given in Table 5. The combination of choice of the parameters specified by the TSO shall take possible technology-dependent limitations into account;	30 sekunder	
15	2	d	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 two seconds, 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 two seconds. 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;	Så kort som muligt, skal begrundes hvis tid > 2 sekunder.	
15	2	d	v	the power generating module shall be capable of providing full active power frequency response for a period of between 15 and 30 minutes as specified by the relevant TSO. In specifying the period, the TSO shall have regard to active power headroom and primary energy source of the power generating module;	15 minutter.	
15	2	d	vi	within the time limits laid down in point (v) of paragraph (2) (d), active power control must not have any adverse impact on the active power frequency response of power generating modules;	-	
15	2	d	vii	the parameters specified by the relevant TSO in accordance with paragraphs 1, 2, 3points (i), (ii), (iii) and (v)5 shall be notified to the relevant regulatory authority. The modalities of that notification shall	-	

				be specified in accordance with the applicable national regulatory framework; Parameters Ranges or values Active power range related to maximum capacity (frequency response range) 1.5 – 10 % For power generating modules with inertia, the maximum admissible initial delay unless justified otherwise in line with Article 15 (2) (d) (iv) 2 seconds For power generating modules without inertia, the maximum admissible initial delay unless justified otherwise in line with Article 15 (2) (d) (iv) as specified by the relevant TSO. Maximum admissible choice of full activation time, unless longer activation times are allowed by the relevant TSO for reasons of system stability 30 seconds Table 5: Parameters for full activation of active power frequency response resulting from frequency step change (explanation for Figure 6).		
15	2	e		with regard to frequency restoration control, the power generating module shall provide functionalities complying with specifications specified by the relevant TSO, aiming at restoring frequency to its nominal value or maintaining power exchange flows between control areas at their scheduled values;	-	
15	2	f		with regard to disconnection due to underfrequency, power generating facilities capable of acting as a load, including hydro pump-storage power generating facilities, shall be capable of disconnecting their load in case of underfrequency. The requirement referred to in this point does not extend to auxiliary supply;	CE/DK1: 49,0 Hz N/DK2: 48,5 Hz	
15	2	g		with regard to real-time monitoring of FSM:	-	
15	2	g	i	to monitor the operation of active power frequency response, the communication interface shall be equipped to transfer in real time and in a secured manner from the power generating facility to the	Krav og liste defineret jf. A14(5)(d)(i) og (ii)	

<table>
<tr><td></td><td></td><td></td><td></td><td>network control center of the relevant system operator or the relevant TSO, at the request of the relevant system operator or the relevant TSO, at least the following signals:
– 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;</td><td></td><td></td></tr>
<tr><td>15</td><td>2</td><td>g</td><td>ii</td><td>the relevant system operator and the relevant TSO 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.</td><td>Krav og liste defineret jf. A14(5)(d)(i) og (ii)</td><td></td></tr>
<tr><td>15</td><td>3</td><td></td><td></td><td>With regard to voltage stability, type C power generating modules shall be capable of automatic disconnection when voltage at the connection point reaches levels specified by the relevant system operator in coordination with the relevant TSO. The terms and settings for actual automatic disconnection of power generating modules shall be specified by the relevant system operator in coordination with the relevant TSO.</td><td><table><tr><th>Beskyttelses-funktion</th><th>Indstilling (Interval/opløsning)</th><th>Funktionstid (interval/opløsning)</th></tr><tr><td>Overspænding (trin 3)</td><td>1,0 – 1,3 U_c / 0,01
Standard: 1,20 U_c</td><td>0,1 – 5 s / 0,05
Standard: 0,1 s</td></tr><tr><td>Overspænding (trin 2)</td><td>1,0 – 1,3 U_c / 0,01
Standard: 1,15 U_c</td><td>0,1 – 5 s / 0,05
Standard: 0,2 s</td></tr><tr><td>Overspænding (trin 1)</td><td>1,0 – 1,2 U_c / 0,01
Standard: 1,10 U_c</td><td>0,1 – 100 s / 0,1
Standard: 60 s</td></tr><tr><td>Underspænding (trin 1)</td><td>0,2 – 1,0 U_c / 0,01
Standard: 0,85 U_c</td><td>0,1 – 100 s / 0,1
Standard: 50 s</td></tr></table>Uc er den normale driftsspænding i tilslutningspunktet.</td><td></td></tr>
<tr><td>15</td><td>4</td><td></td><td></td><td>Type C power generating modules shall fulfil the following requirements relating to robustness:</td><td>-</td><td></td></tr>
<tr><td>15</td><td>4</td><td>a</td><td></td><td>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;</td><td>-</td><td></td></tr>
</table>

15	4	b		without prejudice to paragraph 4 and 5 of Article 13, 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 Regulation;	-	
15	4	c		power generating modules shall be capable of remaining connected to the network during singlephase or three-phase auto-reclosures on meshed network lines, if applicable to the network to which they are connected. The details of that capability shall be subject to coordination and agreements on protection schemes and settings as referred to in point (b) of Article 14(5).	Anlægget skal være designet til, uden afbrydelse, at kunne tolerere et momentant spændingsfasespring på op til 20° i nettilslutningspunktet.	
15	5			Type C power generating modules shall fulfil the following requirements relating to system restoration:	-	
15	5	a		with regard to black start capability:	-	
15	5	a	i	black start capability is not mandatory without prejudice to the Member State's rights to introduce obligatory rules in order to ensure system security;	-	
15	5	a	ii	power generating facility owners shall, at the request of the relevant TSO, provide a quotation for providing black start capability. The relevant TSO may make such a request if it considers system security to be at risk due to a lack of black start capability in its control area;	-	
15	5	a	iii	a power generating module with black start capability shall be capable of starting from shutdown without any external electrical energy supply within a timeframe specified by the relevant system operator in coordination with the relevant TSO;	Opstart fra dødt net er ikke tilladt for distributionstilsluttede anlæg.	
15	5	a	iv	a power generating module with black start capability shall be able to synchronise within the frequency limits laid down in point (a) of Article 13(1) and, where applicable, voltage limits specified by the relevant system operator or in paragraph 2 of Article 16;(2);	-	

15	5	a	v	a power generating module with black start capability shall be capable of automatically regulating dips in voltage caused by connection of demand;	-	
15	5	a	vi	a power generating module with black start capability shall: – be capable of regulating load connections in block load; – be capable of operating in LFSM-O and LFSM-U, as specified in point (c) of paragraph 2 and Article 13(2); – 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; and – control voltage automatically during the system restoration phase;	-	
15	5			with regard to the capability to take part in island operation:	-	
15	5	b	i	power generating modules shall be capable of taking part in island operation if required by the relevant system operator in coordination with the relevant TSO and: – the frequency limits for island operation shall be those established in accordance with point (a) of Article 13(1); – the voltage limits for island operation shall be those established in accordance with paragraph 3 of Article 15(3) or paragraph 2 of Article 13(2), where applicable;	Produktionsanlæg tilsluttet distributionsnettet skal ikke kunne deltage I område-ø-drift.	
15	5	b	ii	power generating modules shall be able to operate in FSM during island operation, as specified in point (d) of paragraph 2. In the event of a power surplus, power generating modules shall be capable of reducing the active power output from a previous operating point to any new operating point within the P-Q-capability diagram. In that regard, 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;	-	

15	5	b	iii	the method for detecting a change from interconnected system operation to island operation shall be agreed between the power generating facility owner and the relevant system operator in coordination with the relevant TSO. The agreed method of detection must not rely solely on the system operator's switchgear position signals;	Ikke relevant jf. A15(5)(b)(i)	
15	5	b	iv	power generating modules shall be able to operate in LFSM-O and LFSM-U during island operation, as specified in point of paragraph 2 and Article 13(2).	-	
15	5	c		With regard to quick re-synchronisation capability:	-	
15	5	c	i	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 the relevant TSO and the power generating facility;	-	
15	5	c	ii	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 the system operator's switchgear position signals;	-	
15	5	c	iii	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 the relevant TSO, taking into consideration the specific characteristics of prime mover technology.	Synkrone produktionsanlæg: 0 min Elproducerende produktionsanlæg: 0 min da re-synkroniseringstid er < 15 minutter.	
15	6			Type C power generating modules shall fulfil the following general system management requirements:	-	

15	6	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 in order to help preserve system security or to prevent damage to the power generating module. The power generating facility owner and the relevant system operator in coordination with the relevant TSO shall agree on the criteria for detecting loss of angular stability or loss of control;	Produktionsanlægget skal være udstyret med beskyttelse til detektering af polslip eller tab af synkronisme. Ved konstateret polslip eller tab af synkronisme skal produktionsanlægget udkobles momentant af hensyn til "system- og anlægssikkerheden". De anvendte beskyttelsesfunktioner må ikke påvirke produktionsanlæggets "FRT-egenskaber", idet anvendte beskyttelsesindstillinger fastlægges på baggrund af simulering af relevante fejlscenarier.	
15	6	b		with regard to instrumentation:	-	
15	6	b	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; and – frequency. The relevant system operator shall have the right to specify quality of supply parameters to be complied with on condition that reasonable prior notice is given;	For anlæg, der leverer systemydelser, skal der installeres en PMU-enhed til verificering af den specificerede ydelse, herunder produktionsanlæggets dynamiske respons.	
15	6	b	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 the relevant system operator in coordination with the relevant TSO;	Logning skal realiseres via et elektronisk udstyr, der kan opsættes til, som minimum, at logge relevante hændelser for nedennævnte signaler i tilslutningspunktet ved fejl i det kollektive elforsyningssystem og tilsluttet anlæg. - Anlægsejer skal installere et logningsudstyr, der som minimum registrerer: - Spænding for hver fase for anlægget - Strøm for hver fase for anlægget - Aktiv effekt for anlægget (kan være beregnede størrelse)	

- Reaktiv effekt for anlægget (kan være beregnede størrelse)
- Frekvens for anlægget (kan være beregnede størrelse, kan være rotorhastighed (synkrongenerator))
- Aktivering af interne beskyttelsesfunktioner

Specifikke krav til måling, her initiering af logning, kan beskrives i nettilslutningsaftalen.

Logning skal udføres som sammenhængende tidsserier af måleværdier med angivet tid før (-) og efter (+) hændelsestidspunktet.

Logning af hændelser differentieres med udgangspunkt i anlæggets nominelle effekt.

Følgende logninger/filer skal på efterspørgsel leveres:

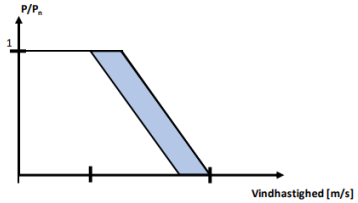
Nominel effekt [MW]	Tidsserie [s]	Type	Sample-frekvens
3 ≤ Pn ≤ 10	-10 til +60	Slow scan	50 Hz, RMS-værdier
10 ≤ Pn ≤ 25	-10 til +60	Slow scan	50 Hz, RMS-værdier
10 ≤ Pn ≤ 25	-0,25 til +2,75	Fast scan	Minimum 1 kHz
Pn ≥ 25	-10 til +60	Slow scan	50 Hz, RMS-værdier
Pn ≥ 25	-3 til +60	Fast scan	Minimum 1 kHz

					Note: ved fast scan logges kun spændinger og strømme. Alle målinger og data, der skal opsamles, skal logges med en tidsstempling og en nøjagtighed, som sikrer, at disse kan korreleres med hinanden og med tilsvarende registreringer i det kol-lektive elforsyningssystem. Logningen skal arkiveres i minimum tre måneder fra fejlsituationen, dog maksimalt op til 100 hændelser. Den relevante DSO og/eller Energinet skal på forlangende have adgang til loggede og rele-vante registrerede informationer.	
15	6	b	iii	the dynamic system behaviour monitoring shall include an oscillation trigger specified by the relevant system operator in coordination with the relevant TSO, with the purpose of detecting poorly damped power oscillations;	Inkluderet i trigger-signaler fra A15(6)(b)ii)	
15	6	b	iv	the facilities for quality of supply and dynamic system behaviour monitoring shall include arrangements for the power generating facility owner, and the relevant system operator and the relevant TSO to access the information. The communications protocols for recorded data shall be agreed between the power generating facility owner, the relevant system operator and the relevant TSO;	Filformat: COMTRADE IEEE C37.111:1999, *IEEE Standard Common Format for Transient Data Exchange (COMTRADE) for Power Systems*	
15	6	c		with regard to the simulation models:	-	
15	6	c	i	at the request of the relevant system operator or the relevant TSO, 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	*Anlæg af type C:* Elforsyningsvirksomheden kan stille samme krav til anlæg over 10 MW som kravene beskrevet i Bilag 3: Kravdokument EU-Forordning 2017/1485 A48(1)(a). *Anlæg af type D:* Jf. Bilag 3: Kravdokument EU-Forordning 2017/1485 A48(1)(a).	

				referred to in Chapters 2, 3 and 4 of Title IV, and shall notify the results of the verification to the relevant system operator or relevant TSO. Member States may require that such verification be carried out by an authorised certifier;	Elforsyningsvirksomheden kan anmode om de samme krav som der stilles af den systemansvarlige virksomhed, hvis elforsyningsvirksomheden vurderer at denne har behov for modellen for at simulerer de dynamiske forhold i distributionsnettet.	
15	6	c	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 the relevant system operator and the power generating facility owner; and – converter models for power park modules;	-	
15	6	c	iii	the request by the relevant system operator referred to in point (i) shall be coordinated with the relevant TSO. It shall include: – 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;	Krav præciseres I A15(6)(c)(i)	
15	6	c	iv	the power generating facility owner shall provide recordings of the power generating module's performance to the relevant system operator or relevant TSO if requested. The relevant system operator	-	

				or relevant TSO may make such a request, in order to compare the response of the models with those recordings;		
15	6	d		with regard to the installation of devices for system operation and devices for system security, if the relevant system operator or the relevant TSO considers that it is necessary to install additional devices in a power generating facility in order to preserve or restore system operation or security, the relevant system operator or relevant TSO and the power generating facility owner shall investigate that matter and agree on an appropriate solution;	Systemværn: For synkrone produktionsanlæg gælder; Krav om synkrongeneratorers behov for systemværn afdækkes når POC er tildelt. For elproducerende produktionsanlæg gælder; Et anlæg skal være udstyret med et systemværn, som er en nødreguleringsfunktion, der på baggrund af en nedreguleringsordre meget hurtigt skal kunne regulere den aktive effekt leveret fra et produktionsanlæg til et eller flere foruddefinerede setpunkter. Setpunkterne fastlægges af elforsyningsvirksomheden ved idriftsættelsen. Anlægget skal have mulighed for minimum fem forskellige konfigurerbare reguleringstrin. Som standardværdier anbefales følgende reguleringstrin: 1. 70 % af Pn 2. 50 % af Pn 3. 40 % af Pn 4. 25 % af Pn 5. 0 % af Pn, dvs. anlægget er stoppet	

					Reguleringen skal påbegyndes inden for 1 sekund og skal være fuldført indenfor 10 sekunder fra modtagelse af ordre om nedregulering. I det tilfælde at der til systemværnet beordres en opregulering, f.eks. fra trin 4 (25 %) til 3 (40 %), accepteres det, at designmæssige grænser for anlæggets generatorer eller øvrige anlægsenheder kan give en forøget tid for fuldførelse af ordren. For anlæg på 10 MW eller derover skal nedreguleringsordren sendes via binære transmittere fra elforsyningsvirksomheden til anlægget. Forbindelsen kan enten være kobber eller fiber efter aftale med elforsyningsvirksomheden. Signalet er et autonomt signal sendt direkte fra systemoperatørens station, hvor anlægget er tilsluttet, til anlægsejers park-regulering, og skal sikre hurtig nedregulering af parken. Elforsyningsvirksomheden stiller krav til, at systemværnet også kan justeres fra PCOM-grænsefladen som beskrevet i signallisten. Det godtages for signaler modtaget fra PCOM-grænsefladen at reguleringen påbegyndes indenfor 5 sekunder og fuldføres inden for 15 sekunder fra modtagelse af ordre om nedregulering. Automatisk nedreguleringsfunktion af aktiv effekt ved stopvindhastighed: Et produktionsanlæg, hvor primær energi er vind, skal kunne nedregulere den aktive effektproduktion, når der optræder høje vindhastigheder, inden vindmøllernes indbyggede beskyttelsesfunktion ved høje vindhastigheder (stopvindhastighed) aktiveres.	

					Produktionsanlægget skal kunne regulere den aktive effekt til en vilkårlig værdi i intervallet fra 100 % til 10 % af Pn. Reguleringsfunktionen skal kunne aktiveres / de-aktiveres via ordrer. Nedregulering kan foretages som en kontinuert regulering eller en diskret regulering. Diskret regulering må maksimalt have en trinstørrelse på 25 % af Pn inden for det skraverede område vist i Figur x.  Nedreguleringsbåndet aftales med elforsyningsvirksomheden ved idriftsættelse af produktionsanlægget. Bredden af nedreguleringsbåndet kan afhænge af de lokale vindforhold. Den automatiske nedreguleringsfunktion præciseres som minimum ved; - Vindhastighed – Aktivering af nedregulering [m/s] - Vindhastighed – 10 % af Pn - Vindhastighed – cutout [m/s]	

15	6	e		the relevant system operator shall specify, in coordination with the relevant TSO, minimum and maximum limits on rates of change of active power output (ramping limits) in both an up and down direction of change of active power output for a power generating module, taking into consideration the specific characteristics of prime mover technology;	Op: Min: 1 % af Pn/min Op: Max: 20 % af Pn dog højest 60 MW/min Ned: Min: 1 % af Pn/min Ned: Max: 20 % af Pn dog højest 60 MW/min Kravene til minimum og maksimum gradienter for ændring af aktiv effekt er gældende, hvis andre betingelser/regler ikke fastsætter respektive gradienter herunder også systemydelser, energimarked etc.	
15	6	f		earthing arrangement of the neutral-point at the network side of step-up transformers shall comply with the specifications of the relevant system operator.	Forhold omkring jording af produktionsanlægget skal aftales med elforsyningsvirksomheden.	
General requirements for type D power-generating modules						
16	1			In addition to fulfilling the requirements listed in Article 13, except for Article 13(2)(b), (6) and (7), Article 14, except for Article 14(2), and Article 15, except for Article 15(3), type D power generating modules shall fulfil the requirements set out in this Article.	-	
16	2			Type D power generating modules shall fulfil the following requirements relating to voltage stability:	-	
16	2	a		with regard to voltage ranges:	-	
16	2	a	i	without prejudice to point (a) of Article 14(3) and point (a) of Article 13(3),paragraph 3 a 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 in Tables 6.1 and 6.2;	1 p.u. svarer til den opgivne normal driftsspænding i tilslutningspunktet Uc.	
16	2	a	ii	the relevant TSO may specify shorter periods of time during which power generating modules shall be capable of remaining connected to	n/a	

				the network in the event of simultaneous overvoltage and underfrequency or simultaneous undervoltage and overfrequency;		
16	2	a	iii	notwithstanding the provisions of point (i), the relevant TSO in Spain may require power generating modules be capable of remaining connected to the network in the voltage range between 1.05 pu and 1.0875 pu for an unlimited period;	n/a	
16	2	a	iv	for the 400 kV grid voltage level (or alternatively commonly referred to as 380 kV level) the reference 1 pu value is 400 kV, for other grid voltage levels the reference 1 pu voltage may differ for each system operator in the same synchronous area;	-	
16	2	a	v	notwithstanding the provisions of point (i), the relevant TSOs in the Baltic synchronous area may require power generating modules to remain connected atto the 400kV network in the voltage range limits and for the time periods that apply in the Continental Europe synchronous area. Synchronous area Voltage range Time period for operation Continental Europe 0.85 pu – 0.90 pu 60 minutes 0.90 pu – 1.118 pu Unlimited 1.118 pu – 1.15 pu To be specified by each TSO, but not less than 20 minutes and not more than 60 minutes Nordic 0.90 pu – 1.05 pu Unlimited 1.05 pu – 1.10 pu 60 minutes Great Britain 0.90 pu–1.10 pu Unlimited Ireland and Northern Ireland 0.90 pu – 1.118 pu Unlimited Baltic 0.85 pu – 0.90 pu 30 minutes 0.90 pu – 1.118 pu Unlimited 1.118 pu – 1.15 pu 20 minutes	-	

<table>
<tr><td></td><td></td><td></td><td></td><td>Synchronous area Voltage range Time period for operation
Continental Europe 0.85 pu – 0.90 pu 60 minutes
0.90 pu – 1.05 pu Unlimited
1.05 pu – 1.10 pu To be specified by each TSO, but not less than 20 minutes and not more than 60 minutes
Nordic 0.90 pu – 1.05 pu Unlimited
1.05 pu – 1.10 pu To be specified by each TSO, but not more than 60 minutes
Great Britain 0.90 pu – 1.05 pu Unlimited
1.05 pu – 1.10 pu 15 minutes
Ireland and Northern Ireland 0.90 pu – 1.05 pu Unlimited
Baltic 0.88 pu – 0.90 pu 20 minutes
0.90 pu – 1.097 pu Unlimited 1.097 pu – 1.15 pu 20 minutes</td><td></td><td></td></tr>
<tr><td>16</td><td>2</td><td>b</td><td></td><td>wider voltage ranges or longer minimum time periods for operation may be agreed between the relevant system operator and the power generating facility owner in coordination with the relevant TSO. 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;</td><td>Ej relevant.</td><td></td></tr>
<tr><td>16</td><td>2</td><td>c</td><td></td><td>Without prejudice to point (a), the relevant system operator in coordination with the relevant TSO 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.</td><td><table><tr><td>Beskyttelses-funktion</td><td>Indstilling (Interval/opløsning)</td><td>Funktionstid (interval/opløsning)</td></tr><tr><td>Overspænding (trin 3)</td><td>1,0 – 1,3 U_c / 0,01
Standard: 1,20 U_c</td><td>0,1 – 5 s / 0,05
Standard: 0,1 s</td></tr><tr><td>Overspænding (trin 2)</td><td>1,0 – 1,3 U_c / 0,01
Standard: 1,15 U_c</td><td>0,1 – 5 s / 0,05
Standard: 0,2 s</td></tr><tr><td>Overspænding (trin 1)</td><td>1,0 – 1,2 U_c / 0,01
Standard: 1,10 U_c</td><td>0,1 – 100 s / 0,1
Standard: 60 s</td></tr><tr><td>Underspænding (trin 1)</td><td>0,2 – 1,0 U_c / 0,01
Standard: 0,85 U_c</td><td>0,1 – 100 s / 0,1
Standard: 50 s</td></tr></table>Uc er den normale driftsspænding i tilslutningspunktet.</td><td></td></tr>
</table>

16	3			Type D power generating modules shall fulfil the following requirements in relation to robustness:	-	
16	3	a		with regard to fault-ride-through capability:		
16	3	a	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 the relevant TSO. The voltage-against-time-profile shall express a lower limit of the actual course of the phase-tophase 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. That lower limit shall be specified by the relevant TSO, using the parameters set out in Figure 3 and within the ranges set out in Tables 7.1 and 7.2 for type D power generating modules connected at or above the 110 kV level. That lower limit shall also be specified by the relevant TSO, using parameters set out in Figure 3 and within the ranges set out in Tables 3.1 and 3.2 for type D power generating modules connected below the 110 kV level.;	Krav jf. A14(3)(a)(i)	
16	3	a	ii	each TSO shall specify the pre-fault and post-fault conditions for the fault-ride-through capability referred to in point (iv) of Article 14(3)(a). The specified pre-fault and post-fault conditions for the fault-ride-through capability shall be made publicly available; Voltage parameters [pu] Time parameters [seconds] Uret: 0 tclear: 0.14 – 0.15 (or 0.14 - 0.25 if system protection and secure operation so require) Uclear: 0.25 trec1: tclear – 0.45 Urec1: 0.5 – 0.7 trec2: trec1 – 0.7 Urec2: 0.85 – 0.9 trec3: trec2 – 1.5	Kortslutningskatalog fastlægger metode for beregning af kortslutningseffekt samt beregner konditioner i kendte tilslutningspunkter	

				Table 7.1: Parameters for Figure 3 for fault-ride-through capability of synchronous power generating modules. Voltage parameters [pu] Time parameters [seconds] Uret: 0 tclear: 0.14 – 0.15 (or 0.14 - 0.25 if system protection and secure operation so require) Uclear: Uret trec1: tclear Urec1: Uclear trec2: trec1 Urec2: 0.85 trec3: 1.5 – 3.0 Table 7.2: Parameters for Figure 3 for fault-ride-through capability of power park modules		
16	3	b		at the request of a power generating facility owner, the relevant system operator shall provide the pre-fault and post-fault conditions to be considered for fault-ride-through capability as an outcome of the calculations at the connection point as specified in point (iv) of Article 14(3) (a) regarding:	A14(3)(a)(iv)	
16	3	b	i	pre-fault minimum short circuit capacity at each connection point expressed in MVA;	A14(3)(a)(iv)	
16	3	b	ii	pre-fault operating point of the power generating module expressed as active power output and reactive power output at the connection point and voltage at the connection point; and	Anlægskonditioner: Anlægstolerancen er specificeret ved Pn og Qmin.	
16	3	b	iii	post-fault minimum short circuit capacity at each connection point expressed in MVA;	A14(3)(a)(iv)	
16	3	c		fault-ride-through capabilities in case of asymmetrical faults shall be specified by each TSO.	Angivne FRT-krav gælder for symmetrisk og asymmetriske fejl, hvor referencen er spændingens synkronkomposant	
16	4			Type D power generating modules shall fulfil the following general system management requirements:	-	
16	4	a		with regard to synchronisation, when starting a power generating module, synchronisation shall be performed by the power generating facility owner only after authorisation by the relevant system operator;	-	

16	4	b		the power generating module shall be equipped with the necessary synchronisation facilities;	-	
16	4	c		synchronisation of power generating modules shall be possible at frequencies within the ranges set out in Table 2;	-	
16	4	d		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:	-	
16	4	d	i	voltage;	-	
16	4	d	ii	frequency;	-	
16	4	d	iii	phase angle range;	-	
16	4	d	iv	phase sequence;	-	
16	4	d	v	deviation of voltage and frequency.	-	
Requirements for type B synchronous power-generating modules						
17	1			Type B synchronous power generating modules shall fulfil the requirements listed in Articles 13, except for Article 13(2)(b), and 14.	-	
17	2			Type B synchronous power generating modules shall fulfil the following additional requirements relating to voltage stability:	-	
17	2	a		with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a synchronous power generating module to provide reactive power;	Angivelse af setpunkter skal kunne ske i trin på 1 % af Sn eller bedre for effekter og 0,01 eller bedre for effektfaktor. Reguleringen skal ske med en nøjagtighed på ±2 % af Sn målt over en periode på 1 minut. Det er tilladt at nøjagtigheden er dårligere end ±2 % af Sn, når produktionen af aktiv effekt er under 10 % af Sn. Udvekslingen af ukontrolleret reaktiv effekt må aldrig være større end 10 % af Sn.	

I tilfælde, hvor en eller flere elproducerende enheder i et elproducerende anlæg er ude til revision, accepteres det, at det elproducerende anlægs levering af reaktiv effekt reduceres pro rata i henhold til det antal elproducerende enheder, som er ude til revision.

Effektfaktor regulering:
Et produktionsanlæg skal kunne udføre effektfaktorregulering, så den reaktive effekt kan reguleres ved hjælp af fast effektfaktor.

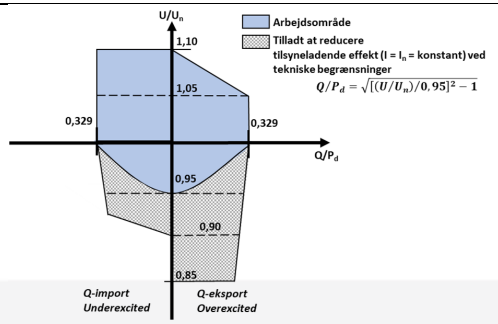
Når et nyt setpunkt for effektfaktoren sættes, skal reguleringen være færdig inden for 1 minut.

Produktionsanlægget skal producere ved en effektfaktor på 1 som standard.

Automatisk effektfaktorregulering:
Et produktionsanlæg skal kunne udføre automatisk effektfaktorregulering med standardindstillingerne for karakteristikken angivet i tabel x.

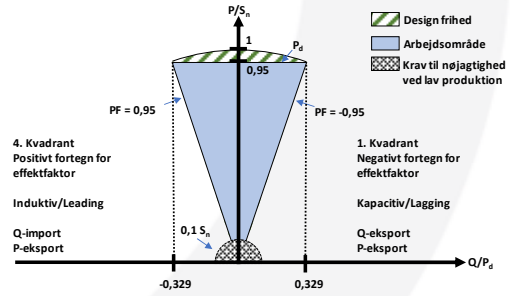
Punkter for karakteristikken		
Punkt	P/Pn	Effektfaktor
1	0,0	1,0
2	0,5	1,0
3	1,0	0,9 induktiv

					Aktiveringsniveauet for funktionen er normalt 105 % af Un, og deaktiveringsniveauet er 100% af Un. For anlæg tilsluttet lavspændingsnettet er Uc lig med Un. Reguleringen af den reaktive effekt skal være færdig inden for 10 sekunder, efter den aktive effekt har stabiliseret sig. Hvis funktionen aktiveres, aftales de aktuelle indstillingsværdier for reguleringsfunktionen med elforsyningsvirksomheden. *Q-regulering:* Et produktionsanlæg skal kunne udføre Q-regulering. Reguleringen fra et setpunkt til et nyt setpunkt skal være udført inden for 1 minut. *<u>Anlæg tilsluttet lavspændingsnettet:</u>* Et synkront produktionsanlæg skal være i stand til at levere reaktiv effekt ved forskellige spændinger i POC, som angivet i figur x.	

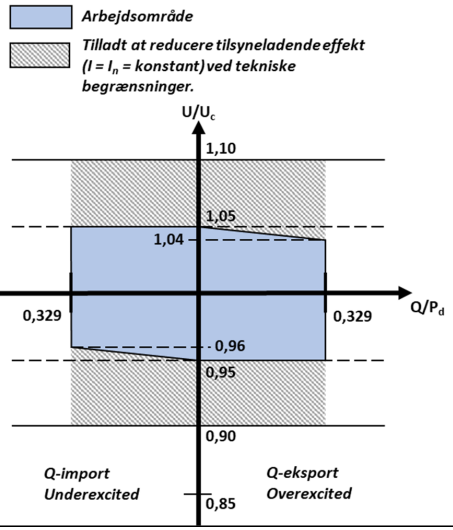


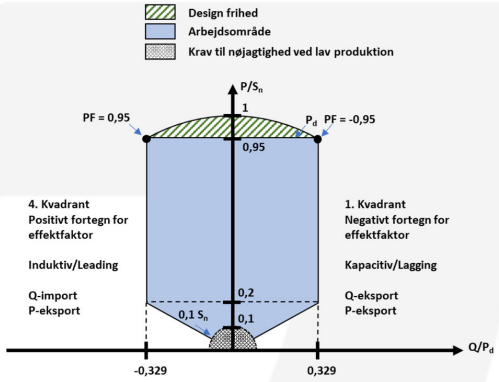
Et synkront produktionsanlæg skal være i stand til at levere reaktiv ved forskellige niveauer af aktiv effekt, som angivet i figur x.

Et synkront produktionsanlæg, hvor Pd er mindre end Pn, er drift inden for området "designfrihed" tilladt. Det synkrone produktionsanlæg må ikke levere en aktiv effekt, som er større end Pn.

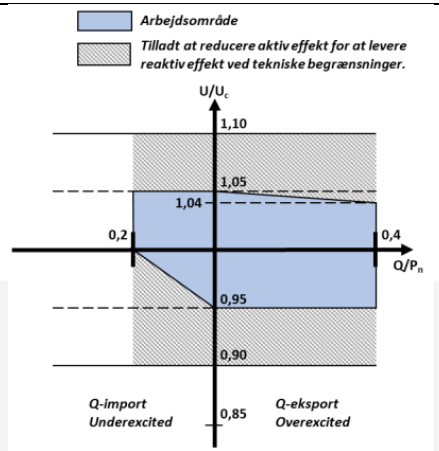


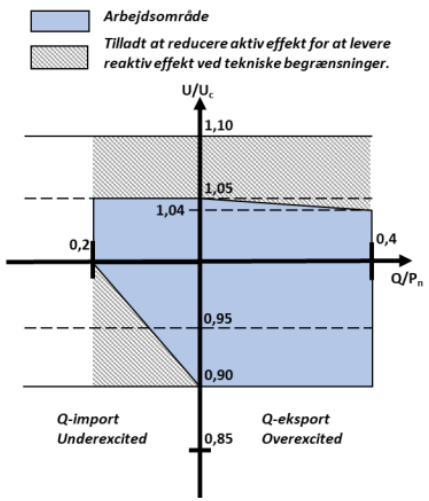
Uden for der beskrevne arbejdsområder skal et synkront produktionsanlæg levere en stabil reaktiv effekt, som skal være i

					overensstemmelse med den valgte reguleringsform, og som kun må være begrænset af enhedens tekniske ydeevne som fx mætning eller underkompensering. *<u>Anlæg tilsluttet mellem- og højspændingsnettet:</u>* Når et produktionsanlæg skal levere eller optage reaktiv effekt, er det tilladt at reducere produktionen af aktiv effekt for at overholde produktionsanlæggets nominelle tilsyneladende effekt. Reduktionen skal være så lille som teknisk muligt. Et synkront produktionsanlæg skal være i stand til at levere reaktiv effekt ved forskellige spændinger i POC, som angivet i figur x.  	

					I det skraverede område skal produktionsanlægget levere en stabil reaktiv effekt, som skal være i overensstemmelse med den valgte reguleringsform, og som kun må være begrænset af enhedens tekniske ydeevne, som fx mætning eller underkompensering. Et produktionsanlæg skal være i stand til at levere reaktiv effekt ved forskellige niveauer af aktiv effekt, som er angivet i figur x.  	
17	2	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.	-	
17	3			With regard to robustness, type B synchronous power generating modules shall be capable of providing post-fault active power	Der specificeres ikke yderlig robustness respons krav end der er specificeret i de øvrige artikler.	

				recovery. The relevant TSO shall specify the magnitude and time for active power recovery.	Anlægsegenskaber for robustness må ikke forsinkes eller begrænses ved et specifikt design med udgangspunkt i denne artikel.	
Requirements for type C synchronous power-generating modules						
18	1			Type C synchronous power generating modules shall fulfil the requirements laid down in Articles 13, 14, 15 and 17, except for Article 13 (2)(b) and 13(6), Article 14(2) and Article 17(2)(a).	-	
18	2			Type C synchronous power generating modules shall fulfil the following additional requirements in relation to voltage stability:	-	
18	2	a		with regard to reactive power capability, the relevant system operator 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, if no step-up transformer exists. This supplementary reactive power shall compensate the reactive power demand of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the synchronous power generating module or its alternator terminals, if no step-up transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.	Det påhviler anlægsejer at kompensere for anlægsinfrastrukturens reaktive effekt i situationer, hvor anlægget er udkoblet eller ikke producerer aktiv effekt.	
18	2	b		with regard to reactive power capability at maximum capacity:	-	
18	2	b	i	the relevant system operator in coordination with the relevant TSO shall specify the reactive power provision capability requirements in the context of varying voltage. For that purpose the relevant system operator shall specify a U-Q/Pmax-profile within the boundaries of which the synchronous power generating module shall be capable of providing reactive power at its maximum capacity. The specified U-Q/Pmax profile may take any shape, having regard to the potential	For C-anlæg:	

				costs of delivering the capability to provide reactive power production at high voltages and reactive power consumption at low voltages;	 For D-anlæg:	

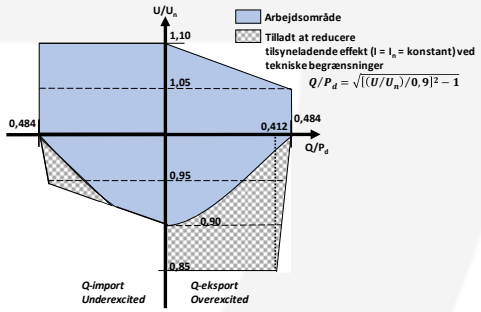
						
18	2	b	ii	the U-Q/Pmax-profile shall be specified by the relevant system operator in coordination with the relevant TSO, in conformity with the following principles: – the U-Q/Pmax-profile shall not exceed the U-Q/Pmax-profile envelope, represented by the inner envelope in Figure 7; – the dimensions of the U-Q/Pmax-profile envelope (Q/Pmax range and voltage range) shall be within the range specified for each synchronous area in Table 8; and – the position of the U-Q/Pmax-profile envelope shall be within the limits of the fixed outer envelope in Figure 7; Figure 7: U-Q/Pmax-profile of a synchronous power generating module. The diagram represents boundaries of a U-Q/Pmax-profile by	-	

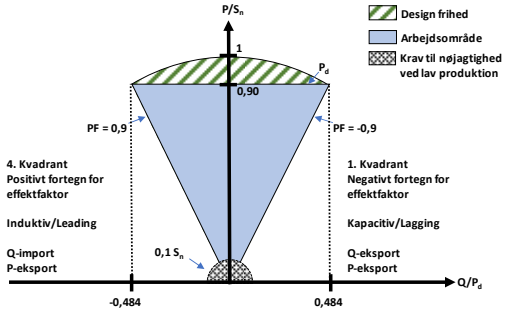
				the voltage at the connection point, expressed by the ratio of its actual value and its the reference 1 pu value, against the ratio of the reactive power (Q) and the maximum capacity (Pmax). The position, size and shape of the inner envelope are indicative. Synchronous area Maximum range of Q/Pmax Maximum range of steady-state voltage level in PU Continental Europe 0.95 0.225 Nordic 0.95 0.150 Great Britain 0.95 0.225 Ireland and Northern Ireland 1.08 0.218 Baltic 1.0 0.220 Table 8: Parameters for the inner envelope in Figure 7		
18	2	b	iii	the reactive power provision capability requirement applies at the connection point. For profile shapes other than rectangular, the voltage range represents the highest and lowest values. The full reactive power range is therefore not expected to be available across the range of steady-state voltages;	-	
18	2	b	iv	the synchronous power generating module shall be capable of moving to any operating point within its U-Q/Pmax profile in appropriate timescales to target values requested by the relevant system operator;	-	
18	2	c		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,	Angivelse af setpunkter skal kunne ske i trin på 100 kVAr eller bedre for effekter og 0,01 eller bedre for effektfaktor. Reguleringen skal ske med en nøjagtighed på ±3% af Q_n eller bedre. Nøjagtigheden for regulering måles over en periode på 1 minut.	

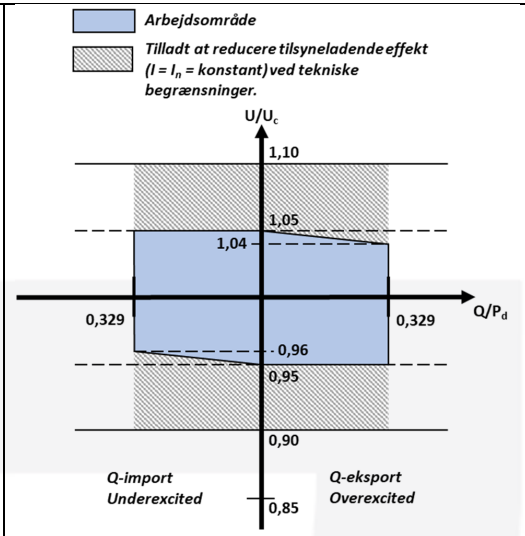
				taking the auxiliary supply power and the active and reactive power losses of the step-up transformer, if applicable, into account.		
Requirements for type D synchronous power-generating modules						
19	1			Type D synchronous power generating modules shall fulfil the requirements laid down in Article 13, except for Article 13(2)(b), (6) and (67), Article 14 except for Article 14(2), Article 15, except for Article 15(3), Article 16, Article 17, except for Article 17(2) and Article 18.	-	
19	2			Type D synchronous power generating modules shall fulfil the following additional requirements in relation to voltage stability:	-	
19	2	a		the parameters and settings of the components of the voltage control system shall be agreed between the power generating facility owner and the relevant system operator, in coordination with the relevant TSO;	Se note bagerst i dokumentet.	
19	2	b		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:	-	
19	2	b	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;	-	
19	2	b	ii	an underexcitation limiter to prevent the AVR from reducing the alternator excitation to a level which would endanger synchronous stability;	-	
19	2	b	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;	-	

19	2	b	iv	a stator current limiter; and	-	
19	2	b	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.	D-anlæg	
19	2	b	vi	The relevant TSO 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.	Der specificeres ikke yderlige vinkelstabilitetskrav end der er specificeret i de øvrige artikler.	
Requirements for type B power park modules						
20	1			Type B power park modules shall fulfil the requirements laid down in Articles 13, except for Article 13(2)(b), and Article 14.	-	
20	2			Type B power park modules shall fulfil the following additional requirements in relation to voltage stability:	-	
20	2	a		with regard to reactive power capability, the relevant system operator shall have the right to specify the capability of a power park module to provide reactive power;	Angivelse af setpunkter skal kunne ske i trin på 1 % af Sn eller bedre for effekter og 0,01 eller bedre for effektfaktor. Reguleringen skal ske med en nøjagtighed på ±2 % af Sn målt over en periode på 1 minut. Det er tilladt at nøjagtigheden er dårligere end ±2 % af Sn, når produktionen af aktiv effekt er under 10 % af Sn. Udvekslingen af ukontrolleret reaktiv effekt må aldrig være større end 10 % af Sn. I tilfælde, hvor en eller flere elproducerende enheder i et elproducerende anlæg er ude til revision, accepteres det, at det elproducerende anlægs levering af reaktiv effekt reduceres pro rata i henhold til det antal elproducerende enheder, som er ude til revision. *Effektfaktor regulering:*	

					Et produktionsanlæg skal kunne udføre effektfaktorregulering, så den reaktive effekt kan reguleres ved hjælp af fast effektfaktor. Når et nyt setpunkt for effektfaktoren sættes, skal reguleringen være færdig inden for 1 minut. Produktionsanlægget skal producere ved en effektfaktor på 1 som standard. *Automatisk effektfaktorregulering:* Et produktionsanlæg skal kunne udføre automatisk effektfaktorregulering med standardindstillingerne for karakteristikken angivet i tabel x. Punkter for karakteristikken Punkt / P/Pn / Effektfaktor 1 / 0,0 / 1,0 2 / 0,5 / 1,0 3 / 1,0 / 0,9 induktiv Aktiveringsniveauet for funktionen er normalt 105 % af Un, og deaktiveringsniveauet er 100% af Un. For anlæg tilsluttet lavspændingsnettet er Uc lig med Un. Reguleringen af den reaktive effekt skal være færdig inden for 10 sekunder, efter den aktive effekt har stabiliseret sig. Hvis funktionen aktiveres, aftales de aktuelle indstillingsværdier for reguleringsfunktionen med elforsyningsvirksomheden.	

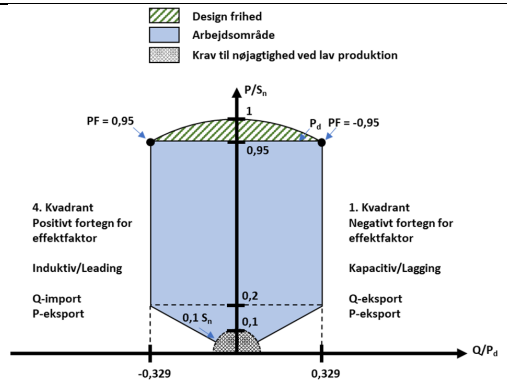
					Q-regulering: Et produktionsanlæg skal kunne udføre Q-regulering. Reguleringen fra et setpunkt til et nyt setpunkt skal være udført inden for 1 minut. *<u>Anlæg tilsluttet lavspændingsnettet:</u>* Et elproducerende produktionsanlæg skal være i stand til at levere reaktiv effekt ved forskellige spændinger i POC, som angivet i figur x.  Et elproducerende produktionsanlæg skal være i stand til at levere reaktiv ved forskellige niveauer af aktiv effekt, som angivet i figur x.	

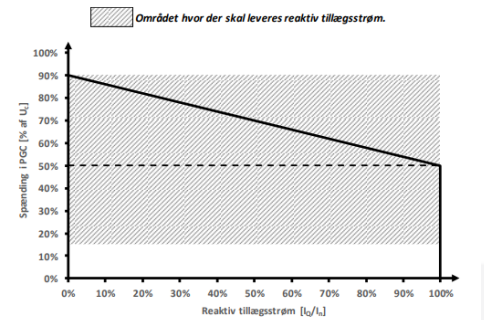
					Et elproducerende produktionsanlæg, hvor Pd er mindre end Pn, er drift inden for området "designfrihed" tilladt. Det elproducerende anlæg må ikke levere en aktiv effekt, som er større end Pn.  Uden for der beskrevne arbejdsområder skal et elproducerende anlæg levere en stabil reaktiv effekt, som skal være i overensstemmelse med den valgte reguleringsform, og som kun må være begrænset af enhedens tekniske ydeevne som fx mætning eller underkompensering. *<u>Anlæg tilsluttet mellem- og højspændingsnettet:</u>* Når et produktionsanlæg skal levere eller optage reaktiv effekt, er det tilladt at reducere produktionen af aktiv effekt for at overholde produktionsanlæggets nominelle tilsyneladende effekt. Reduktionen skal være så lille som teknisk muligt. Et synkront produktionsanlæg skal være i stand til at levere reaktiv effekt ved forskellige spændinger i POC, som angivet i figur x.	



I det skraverede område skal produktionsanlægget levere en stabil reaktiv effekt, som skal være i overensstemmelse med den valgte reguleringsform, og som kun må være begrænset af enhedens tekniske ydeevne, som fx mætning eller underkompensering.

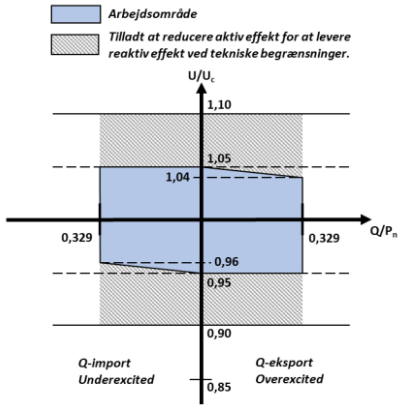
Et produktionsanlæg skal være i stand til at levere reaktiv effekt ved forskellige niveauer af aktiv effekt, som er angivet i figur x.

						
20	2	b		the relevant system operator in coordination with the relevant TSO 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:	Reaktiv tillægsstrøm, I_Q, skal leveres i generatortilslutningspunktet. Anlægget skal kunne levere en reaktiv tillægsstrøm (synkronkomposant) ved spændingsdyk under 90 % af den normale driftsspænding i generatortilslutningspunktet. Regulering af en reaktiv tillægsstrøm skal følge figur x. Den reaktive tillægsstrøm skal kunne leveres inden for 100 ms med en nøjagtighed på ±20 % af I_n.	

					 I det skraverede område på figur x har levering af reaktiv tillægsstrøm første prioritet, mens levering af aktiv effekt har anden prioritet. Med henblik til asymmetrisk fejlstrømsinjektion kan dette aftales med elforsyningsvirksom-heden, i det omfang teknologien har mulighed for at respondere med asymmetrisk fejlstrøm i forbindelse med asymmetriske fejl, så længe krav til levering af reaktiv tillægsstrøm overholdes.	
20	2	b	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;	-	
20	2	b	ii	the relevant system operator in coordination with the relevant TSO shall specify:	Uc < 0,9 pu: start Uc > 0,9 pu: stop	

				– 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, for which current and voltage may be measured differently from the method specified in Article 2; – the timing and accuracy of the fast fault current, which may include several stages during a fault and after its clearance;	Karakteristik af reaktiv tillægsstrøm er specificeret under A20(2)(b).	
20	2	c		with regard to the supply of fast fault current in case of asymmetrical (1-phase or 2-phase) faults, the relevant system operator in coordination with the relevant TSO shall have the right to specify a requirement for asymmetrical current injection.	Ingen krav om asymmetrisk fejlstrømsinjektion for nuværende.	
20	3			Type B power park modules shall fulfil the following additional requirements in relation to robustness:	-	
20	3	a		the relevant TSO shall specify the post-fault active power recovery that the power park module is capable of providing and shall specify:	Anlægget skal efter et indsvingningsforløb levere normal produktion senest 5 sekunder efter, at driftsforholdene i nettilslutningspunktet er tilbage i området kontinuert drift. Effektreguleringen skal ske med en gradient på mindst 20 % af anlæggets nominelle effekt.	
20	3	a	i	when the post-fault active power recovery begins, based on a voltage criterion;	-	
20	3	a	ii	a maximum allowed time for active power recovery; and	-	
20	3	a	iii	a magnitude and accuracy for active power recovery;	-	
20	3	b		the specifications shall be in accordance with the following principles:	-	
20	3	b	i	interdependency between fast fault current requirements according to points (b) and (c) of paragraph (2) and active power recovery;	-	
20	3	b	ii	dependence between active power recovery times and duration of voltage deviations;	-	

20	3	b	iii	a specified limit of the maximum allowed time for active power recovery;	-	
20	3	b	iv	adequacy between the level of voltage recovery and the minimum magnitude for active power recovery; and	-	
20	3	b	v	adequate damping of active power oscillations.	-	
Requirement for type C power park modules						
21	1			Type C power park modules shall fulfil the requirements listed in Articles 13, except for Article 13(2)(b) and (6), Article 14, except for Article 14(2), Article 15 and Article 20, except for Article 20(2)(a), unless referred to otherwise in point (v) of paragraph (3)(d).	-	
21	2			Type C power park modules shall fulfil the following additional requirements in relation to frequency stability:	-	
21	2	a		the relevant TSO shall have the right to specify that power park modules be capable of providing synthetic inertia during very fast frequency deviations;	Krav til syntetisk inerti er ikke specificeret. Behov for syntetisk inerti vil blive påbegyndt afklaret i perioden 2018-2019.	
21	2	b		the operating principle of control systems installed to provide synthetic inertia and the associated performance parameters shall be specified by the relevant TSO.	n/a jf A21(2)(a)	
21	3			Type C power park modules shall fulfil the following additional requirements in relation to voltage stability:	-	
21	3	a		with regard to reactive power capability, the relevant system operator 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. This supplementary reactive power shall compensate the reactive power demand of the high-voltage line or cable between the high-voltage terminals of the step-up transformer of the power park module or its convertor terminals, if no step-up	Det påhviler anlægsejer at kompensere for anlægsinfrastrukturens reaktive effekt i situationer, hvor anlægget er udkoblet eller ikke producerer aktiv effekt.	

				transformer exists, and the connection point and shall be provided by the responsible owner of that line or cable.		
21	3	b		with regard to reactive power capability at maximum capacity:		
21	3	b	i	the relevant system operator in coordination with the relevant TSO shall specify the reactive power provision capability requirements in the context of varying voltage. To that end, it shall specify a U-Q/Pmax-profile that may take any shape within the boundaries of which the power park module shall be capable of providing reactive power at its maximum capacity;	For C-anlæg:  For D-anlæg:	

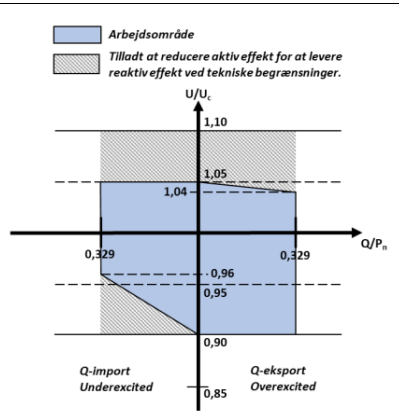
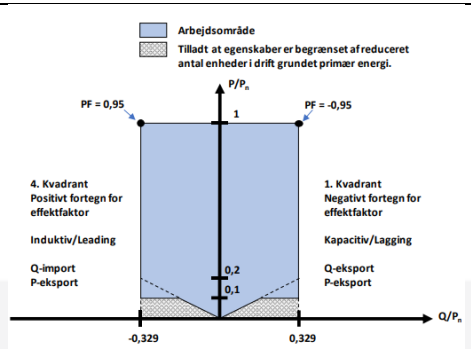
						
21	3	b	ii	the U-Q/Pmax-profile shall be specified by each relevant system operator in coordination with the relevant TSO in conformity with the following principles: – the U-Q/Pmax-profile shall not exceed the U-Q/Pmax-profile envelope, represented by the inner envelope in Figure 8; – the dimensions of the U-Q/Pmax-profile envelope (Q/Pmax range and voltage range) shall be within the values specified for each synchronous area in Table 9; – the position of the U-Q/Pmax-profile envelope shall be within the limits of the fixed outer envelope set out in Figure 8; and – the specified U-Q/Pmax profile may take any shape, having regard to the potential costs of delivering the capability to provide reactive power production at high voltages and reactive power consumption at low voltages;		

				Figure 8: U-Q/Pmax-profile of a power park module. The diagram represents boundaries of a UQ/Pmax-profile by the voltage at the connection point, expressed by the ratio of its actual value and its reference 1 pu value, against the ratio of the reactive power (Q) and the maximum capacity (Pmax). The position, size and shape of the inner envelope are indicative. Synchronous area Maximum range of Q/Pmax Maximum range of steady-state voltage level in PU Continental Europe 0.75 0.225 Nordic 0.95 0.150 Great Britain 0.66 0.225 Ireland and Northern Ireland 0.66 0.218 Baltic 0.80 0.220 Table 9: Parameters for the inner envelope in Figure 8		
21	3	b	iii	the reactive power provision capability requirement applies at the connection point. For profile shapes other than rectangular, the voltage range represents the highest and lowest values. The full reactive power range is therefore not expected to be available across the range of steady-state voltages;	-	
21	3	c		With regard to reactive power capability below maximum capacity:	-	

21	3	c	i	the relevant system operator in coordination with the relevant TSO shall specify the reactive power provision capability requirements and shall specify a P-Q/Pmax-profile that may take any shape within the boundaries of which the power park module shall be capable of providing reactive power below maximum capacity;		
21	3	c	ii	the P-Q/Pmax-profile shall be specified by each relevant system operator in coordination with the relevant TSO, in conformity with the following principles: – the P-Q/Pmax-profile shall not exceed the P-Q/Pmax-profile envelope, represented by the inner envelope in Figure 9; – the Q/Pmax range of the P-Q/Pmax-profile envelope is specified for each synchronous area in Table 9; – the active power range of the P-Q/Pmax-profile envelope at zero reactive power shall be 1 pu; – the P-Q/Pmax-profile can be of any shape and shall include conditions for reactive power capability at zero active power; and – the position of the P-Q/Pmax-profile envelope shall be within the limits of the fixed outer envelope set out in Figure 9;	-	
21	3	c	iii	when operating at an active power output below maximum capacity (P<Pmax), the power park module shall be capable of providing reactive power at any operating point inside its P-Q/Pmaxprofile, if all units of that power park module which generate power are technically available that is to say they are not out of service due to maintenance	-	

				or failure, otherwise there may be less reactive power capability, taking into consideration the technical availabilities;		
21	3	c	iv	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 the relevant system operator;	-	
21	3	d		with regard to reactive power control modes:	-	
21	3	d	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;	-	
21	3	d	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;	-	
21	3	d	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 %;	-	
21	3	d	iv	following a step change in voltage, the power park module shall be capable of achieving 90 % of the change in reactive power output within a time t1 to be specified by the relevant system operator in the range of 1 to 5 seconds, and must settle at the value specified by the slope within a time t2 to be specified by the relevant system operator in the range of 5 to 60 seconds, with a steadystate reactive tolerance no greater than 5 % of the maximum reactive power. The relevant system operator shall specify the time specifications;	t1: 1-5 sec: t1 = 1 sek. t2: 5-60 sec: t2 = 5 sek.	
21	3	d	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 point (a) of Article	-	

				20(2) and by points (a) and (b) of Article 21(3), 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;		
21	3	d	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, specified by the relevant system operator according to point (a) of Article 20(2) or specified by points (a) and (b) of Article 1821(3), with a target power factor in steps no greater than 0.01. The relevant system operator 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. The tolerance of the target power factor shall be expressed through the tolerance of its corresponding reactive power. This reactive power tolerance shall be expressed by either an absolute value or by a percentage of the maximum reactive power of the power park module;	Target: Opløsning på 0.01 Tolerance og tid til nyt setpunkt: For reguleringsfunktionen gælder, at nøjagtigheden for en fuldført regulering, over en periode på 1 minut, maksimalt må afvige ±2 % af Qn. Regulering til et nyt setpunkt for effektfaktor skal påbegyndes inden for 2 sekunder og skal være fuldført inden for 30 sekunder fra modtagelse af ordre om setpunktsændring	
21	3	d	vii	the relevant system operator, in coordination with the relevant TSO and with the power park module owner, shall specify which of the above three reactive power control mode options and associated setpoints is to apply, and what further equipment is needed to make the adjustment of the relevant setpoint operable remotely;	Driftsmode betinget af ydelseslevering. Hvor der anvendes viklingskobler på maskintransformer/nettransformer, kan det aftales med den systemansvarlige virksomhed, at viklingskobleren må anvendes til opfyldelse af krav til reaktive reguleringsegenskaber. Hvis aftale indgås skal det fremgå af nettilslutningsaftalen for anlægget. Hvis der anvendes viklingskobler på maskintransformeren/nettransformer, er anlægsejer ansvarlig for den rette koordinering mellem anlæggets reaktive reguleringsfunktioner og viklingskoblerreguleringen	

21	3	e		with regard to prioritising active or reactive power contribution, the relevant TSO 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;	Reaktiv strøm prioriteres	
21	3	f		with regard to power oscillations damping control, if specified by the relevant TSO a power park module shall be capable of contributing to damping power oscillations. The voltage and reactive power control characteristics of power park modules must not adversely affect the damping of power oscillations.	PPM POD behov og performance afklares med aktørinddragelse i 2018/2019.	
Requirements for type D power park modules						
22				Type D power park modules shall fulfil the requirements listed in Articles 13, except for Article 13(2)(b), (6) and (7), Article 14, except for Article 14(2), Article 15, except for Article 15(3), Article 16, Article 20 except for Article 20(2)(a) and Article 21.	-	
General provisions						
29	1			The power-generating facility owner shall demonstrate to the relevant system operator that it has complied with the requirements set out in Title II of this Regulation by completing successfully the operational notification procedure for connection of each power-generating module described in Articles 30 to 37.	Offentligt gjort i bilag til de tekniske betingelser.	
29	2			The relevant system operator shall clarify and make publicly available the details of the operational notification procedure.	-	
Operational notification of type A power-generating modules						
30	1			The operational notification procedure for connection of each new type A power-generating module shall consist of submitting an installation document. The power-generating facility owner shall ensure that the required information is filled in on an installation document obtained from the relevant system operator and is	-	

				submitted to the system operator. Separate installation documents shall be provided for each power-generating module within the power-generating facility. The relevant system operator shall ensure that the required information can be submitted by third parties on behalf of the power-generating facility owner.		
30	2			The relevant system operator shall specify the content of the installation document, which shall have at least the following information:	-	
30	2	a		the location at which the connection is made;	-	
30	2	b		the date of the connection;	-	
30	2	c		the maximum capacity of the installation in kW;	-	
30	2	d		the type of primary energy source;	-	
30	2	e		the classification of the power-generating module as an emerging technology according to Title VI of this Regulation;	-	
30	2	f		reference to equipment certificates issued by an authorised certifier used for equipment that is in the site installation;	-	
30	2	g		as regards equipment used, for which an equipment certificate has not been received, information shall be provided as directed by the relevant system operator; and	-	
30	2	h		the contact details of the power-generating facility owner and the installer and their signatures.	-	
30	3			The power-generating facility owner shall ensure that the relevant system operator or the competent authority of the Member State is notified about the permanent decommissioning of a power-generating module in accordance with national legislation	-	

				The relevant system operator shall ensure that such notification can be made by third parties, including aggregators		
Operational notification of type B, C and D power-generating modules						
31				The operational notification procedure for connection of each new type B, C and D power-generating module shall allow the use of equipment certificates issued by an authorised certifier.	-	
Procedure for type B and C power-generating modules						
32	1			For the purpose of operational notification for connection of each new type B and C power-generating module, a power-generating module document ('PGMD') shall be provided by the power-generating facility owner to the relevant system operator and shall include a statement of compliance. For each power-generating module within the power-generating facility, separate independent PGMDs shall be provided.	-	
32	2			The format of the PGMD and the information to be given therein shall be specified by the relevant system operator. The relevant system operator shall have the right to request that the power-generating facility owner include the following in the PGMD:	Offentliggjort i bilag på Green Power Denmarks hjemmeside.	
32	2	a		evidence of an agreement on the protection and control settings relevant to the connection point between the relevant system operator and the power-generating facility owner;	-	
32	2	b		itemised statement of compliance;	-	
32	2	c		detailed technical data of the power-generating module with relevance to the grid connection as specified by the relevant system operator;	-	
32	2	d		equipment certificates issued by an authorised certifier in respect of power-generating modules, where these are relied upon as part of the evidence of compliance;	-	

32	2	e		for Type C power-generating modules, simulation models pursuant to point (c) of Article 15(6);	-	
32	2	f		compliance test reports demonstrating steady-state and dynamic performance as required by Chapters 2, 3 and 4 of Title IV, including use of actual measured values during testing, to the level of detail required by the relevant system operator; and	-	
32	2	g		studies demonstrating steady-state and dynamic performance as required by Chapters 5, 6 or 7 of Title IV, to the level of detail required by the relevant system operator.	-	
32	3			The relevant system operator, on acceptance of a complete and adequate PGMD, shall issue a final operational notification to the power-generating facility owner.	-	
32	4			The power-generating facility owner shall notify the relevant system operator or the competent authority of the Member State about the permanent decommissioning of a power-generating module in accordance with national legislation.	-	
32	5			Where applicable, the relevant system operator shall ensure that the commissioning and decommissioning of Type B and Type C power-generating modules can be notified electronically.	-	
32	6			Member States may provide that the PGMD shall be issued by an authorised certifier.	-	
Procedure for type D power-generating modules						
33	1			The operational notification procedure for connection of each new type D power-generating module shall comprise:	-	
33	1	a		energisation operational notification (‘EON’);	-	
33	1	b		interim operational notification (‘ION’); and	-	
33	1	c		final operational notification (‘FON’).	-	
Energisation operational notification for type D power-generating modules						

34	1			An EON shall entitle the power-generating facility owner to energise its internal network and auxiliaries for the power-generating modules by using the grid connection that is specified for the connection point.	-	
34	2			An EON shall be issued by the relevant system operator, subject to completion of preparations including agreement on the protection and control settings relevant to the connection point between the relevant system operator and the power-generating facility owner.	-	
Interim operational notification for type D power-generating modules						
35	1			An ION shall entitle the power-generating facility owner to operate the power-generating module and generate power by using the grid connection for a limited period of time.	-	
35	2			An ION shall be issued by the relevant system operator, subject to completion of the data and study review process as required by this Article.	-	
35	3			With regard to the data and study review, the relevant system operator shall have the right to request that the power-generating facility owner provide the following:	-	
35	3	a		itemised statement of compliance;	-	
35	3	b		detailed technical data on the power-generating module of relevance to the grid connection as specified by the relevant system operator;	-	
35	3	c		equipment certificates issued by an authorised certifier in respect of power-generating modules, where they are relied upon as part of the evidence of compliance;	-	
35	3	d		simulation models, as specified by point (c) of Article 15(6) and required by the relevant system operator;	-	
35	3	e		studies demonstrating the expected steady-state and dynamic performance as required by Chapter 5, 6 or 7 of Title IV; and	-	
35	3	f		details of intended compliance tests in accordance with Chapters 2, 3 and 4 of Title IV.	-	

35	4			The maximum period during which the power-generating facility owner may maintain ION status shall be 24 months. The relevant system operator is entitled to specify a shorter ION validity period. An extension of the ION shall be granted only if the power-generating facility owner has made substantial progress towards full compliance. Outstanding issues shall be clearly identified at the time of requesting extension.	-	
35	5			An extension of the period during which the power-generating facility owner may maintain ION status, beyond the period established in paragraph 4, may be granted if a request for a derogation is made to the relevant system operator before the expiry of that period in accordance with the derogation procedure laid down in Article 60.	-	
Final operational notification for type D power-generating modules						
36	1			A FON shall entitle the power-generating facility owner to operate a power-generating module by using the grid connection.	-	
36	2			A FON shall be issued by the relevant system operator, upon prior removal of all incompatibilities identified for the purpose of ION status and subject to completion of the data and study review process as required by this Article.	-	
36	3			For the purposes of the data and study review, the power-generating facility owner must submit the following to the relevant system operator:	-	
36	3	a		an itemised statement of compliance; and	-	
36	3	b		an update of applicable technical data, simulation models and studies as referred to in points (b), (d) and (e) of Article 35(3), including the use of actual measured values during testing.	-	
36	4			If incompatibility is identified in connection with the issuing of the FON, a derogation may be granted upon a request made to the relevant system operator, in accordance with the derogation procedure described in Title V. A FON shall be issued by the relevant	-	

				system operator if the power-generating module complies with the provisions of the derogation. Where a request for a derogation is rejected, the relevant system operator shall have the right to refuse to allow the operation of the power-generating module until the power-generating facility owner and the relevant system operator resolve the incompatibility and the relevant system operator considers that the power-generating module complies with the provisions of this Regulation. If the relevant system operator and the power-generating facility owner do not resolve the incompatibility within a reasonable time frame, but in any case not later than six months after the notification of the rejection of the request for a derogation, each party may refer the issue for decision to the regulatory authority		
Limited operational notification for type D power-generating modules						
37	1			Power-generating facility owners to whom a FON has been granted shall inform the relevant system operator immediately in the following circumstances:	-	
37	1	a		the facility is temporarily subject to either significant modification or loss of capability affecting its performance; or	-	
37	1	b		equipment failure leading to non-compliance with some relevant requirements.	-	
37	2			The power-generating facility owner shall apply to the relevant system operator for a LON, if the power-generating facility owner reasonably expects the circumstances described in paragraph 1 to persist for more than three months.	-	
37	3			A LON shall be issued by the relevant system operator and shall contain the following information which shall be clearly identifiable:	-	
37	3	a		the unresolved issues justifying the granting of the LON;	-	

37	3	b		the responsibilities and timescales for the expected solution; and	-	
37	3	c		a maximum period of validity which shall not exceed 12 months. The initial period granted may be shorter with the possibility of an extension if evidence is submitted to the satisfaction of the relevant system operator demonstrating that substantial progress has been made towards achieving full compliance.	-	
37	4			The FON shall be suspended during the period of validity of the LON with regard to the items for which the LON has been issued.	-	
37	5			A further extension of the period of validity of the LON may be granted upon a request for a derogation made to the relevant system operator before the expiry of that period, in accordance with the derogation procedure described in Title V.	-	
37	6			The relevant system operator shall have the right to refuse to allow the operation of the power-generating module, once the LON is no longer valid. In such cases, the FON shall automatically become invalid.	-	
37	7			If the relevant system operator does not grant an extension of the period of validity of the LON in accordance with paragraph 5 or if it refuses to allow the operation of the power-generating module once the LON is no longer valid in accordance with paragraph 6, the power-generating facility owner may refer the issue for decision to the regulatory authority within six months after the notification of the decision of the relevant system operator.	-	
Common provisions for compliance testing						
42	1			Testing of the performance of individual power-generating modules within a power-generating facility shall aim at demonstrating that the requirements of this Regulation have been complied with.	-	
42	2			Notwithstanding the minimum requirements for compliance testing set out in this Regulation, the relevant system operator is entitled to:	-	

42	2	a		allow the power-generating facility owner to carry out an alternative set of tests, provided that those tests are efficient and suffice to demonstrate that a power-generating module complies with the requirements of this Regulation;	-	
42	2	b		require the power-generating facility owner to carry out additional or alternative sets of tests in those cases where the information supplied to the relevant system operator in relation to compliance testing under the provisions of Chapter 2, 3 or 4 of Title IV, is not sufficient to demonstrate compliance with the requirements of this Regulation; and	Der skal foretages overensstemmelsesprøvning for både spændingsregulering, effektfaktorregulering og Q-regulering. Der skal foretages prøvning af signaludvekslingen med anlægget.	
42	2	c		require the power-generating facility owner to carry out appropriate tests in order to demonstrate a powergenerating module's performance when operating on alternative fuels or fuel mixes. The relevant system operator and the power-generating facility owner shall agree on which types of fuel are to be tested.	-	
42	3			The power-generating facility owner is responsible for carrying out the tests in accordance with the conditions laid down in Chapters 2, 3 and 4 of Title IV. The relevant system operator shall cooperate and not unduly delay the performance of the tests.	-	
42	4			The relevant system operator may participate in the compliance testing either on site or remotely from the system operator's control centre. For that purpose, the power-generating facility owner shall provide the monitoring equipment necessary to record all relevant test signals and measurements as well as ensure that the necessary representatives of the power-generating facility owner are available on site for the entire testing period. Signals specified by the relevant system operator shall be provided if, for selected tests, the system operator wishes to use its own equipment to record performance. The relevant system operator has sole discretion to decide about its participation.	-	

Kommenterede [PE1]: Har vi ret til dette? I forhold til at der står i artikel 48, stk 10 at den relevante systemoperatør kun kan vælge én af funktionerne?

Common provisions on compliance simulation						
43	1			Simulation of the performance of individual power-generating modules within a power-generating facility shall aim at demonstrating that the requirements of this Regulation have been fulfilled.	-	
43	2			Notwithstanding the minimum requirements set out in this Regulation for compliance simulation, the relevant system operator may:	-	
43	2	a		allow the power-generating facility owner to carry out an alternative set of simulations, provided that those simulations are efficient and suffice to demonstrate that a power-generating module complies with the requirements of this Regulation or with national legislation; and	-	
43	2	b		require the power-generating facility owner to carry out additional or alternative sets of simulations in those cases where the information supplied to the relevant system operator in relation to compliance simulation under the provisions of Chapter 5, 6 or 7 of Title IV, is not sufficient to demonstrate compliance with the requirements of this Regulation.	-	
43	3			To demonstrate compliance with the requirements of this Regulation, the power-generating facility owner shall provide a report with the simulation results for each individual power-generating module within the power-generating facility. The power-generating facility owner shall produce and provide a validated simulation model for a given power-generating module. The scope of the simulation models is set out in point (c) of Article 15(6).	-	
43	4			The relevant system operator shall have the right to check that a power-generating module complies with the requirements of this Regulation by carrying out its own compliance simulations based on the provided simulation reports, simulation models and compliance test measurements.	-	
43	5			The relevant system operator shall provide the power-generating facility owner with technical data and a simulation model of the	-	

				network, to the extent necessary to carry out the requested simulations in accordance with Chapter 5, 6 or 7 of Title IV.		
Compliance test for type B synchronous power-generating modules						
44	1			Power-generating facility owners shall undertake LFSM-O response compliance tests in relation to type B synchronous power-generating modules. Instead of carrying out the relevant test, power-generating facility owners may rely upon equipment certificates issued by an authorised certifier to demonstrate compliance with the relevant requirement. In such a case, the equipment certificates shall be provided to the relevant system operator.	-	
44	2			The following requirements with regard to the LFSM-O response test shall apply:	-	
44	2	a		the power-generating module's technical capability to continuously modulate active power to contribute to frequency control in case of any large increase of frequency in the system shall be demonstrated. The steady-state parameters of regulations, such as droop and deadband, and dynamic parameters, including frequency step change response shall be verified;	-	
44	2	b		the test shall be carried out by simulating frequency steps and ramps big enough to trigger at least 10 % of maximum capacity change in active power, taking into account the droop settings and the deadband. If required, simulated frequency deviation signals shall be injected simultaneously at both the speed governor and load controller of the control systems, taking into account the scheme of those control systems;	-	
44	2	c		the test shall be deemed successful if the following conditions are fulfilled:	-	

44	2	c	i	the test results, for both dynamic and static parameters, meet the requirements set out in Article 13(2); and	-	
44	2	c	ii	undamped oscillations do not occur after the step change response.	-	
Compliance tests for type C synchronous power-generating modules						
45	1			In addition to the compliance tests for type B synchronous power-generating modules described in Article 44, power-generating facility owners shall undertake the compliance tests set out in paragraphs 2, 3, 4 and 6 of this Article in relation to type C synchronous power-generating modules. Where a power-generating module provides black start capability, power-generating facility owners shall also undertake the tests referred to in paragraph 5. Instead of the relevant test, the power-generating facility owner may use equipment certificates issued by an authorised certifier to demonstrate compliance with the relevant requirement. In that case, the equipment certificates shall be provided to the relevant system operator.	-	
45	2			The following requirements with regard to the LFSM-U response test shall apply:	-	
45	2	a		it shall demonstrate that the power-generating module is technically capable of continuously modulating active power at operating points below maximum capacity to contribute to frequency control in case of a large frequency drop in the system;	-	
45	2	b		the test shall be carried out by simulating appropriate active power load points, with low frequency steps and ramps big enough to trigger active power change of at least 10 % of maximum capacity, taking into account the droop settings and the deadband. If required, simulated frequency deviation signals shall be injected simultaneously into both the speed governor and the load controller references;	-	
45	2	c		the test shall be deemed successful if the following conditions are fulfilled:	-	

45	2	c	i	the test results, for both dynamic and static parameters, comply with point (c) of Article 15(2); and	-	
45	2	c	ii	undamped oscillations do not occur after the step change response.	-	
45	3			The following requirements with regard to the FSM response test shall apply:	-	
45	3	a		it shall demonstrate that the power-generating module is technically capable of continuously modulating active power over the full operating range between maximum capacity and minimum regulating level to contribute to frequency control. The steady-state parameters of regulations, such as droop and deadband and dynamic parameters, including robustness through frequency step change response and large, fast frequency deviations shall be verified;	-	
45	3	b		the test shall be carried out by simulating frequency steps and ramps big enough to trigger the whole active power frequency response range, taking into account the settings of droop and deadband, as well as the capability to actually increase or decrease active power output from the respective operating point. If required, simulated frequency deviation signals shall be injected simultaneously into the references of both the speed governor and the load controller of the unit or plant control system;	-	
45	3	c		the test shall be deemed successful if the following conditions are fulfilled:	-	
45	3	c	i	the activation time of full active power frequency response range as a result of a frequency step change is no longer than required by point (d) of Article 15(2);	-	
45	3	c	ii	undamped oscillations do not occur after the step change response;	-	
45	3	c	iii	the initial delay time complies with point (d) of Article 15(2);	-	

45	3	c	iv	the droop settings are available within the range specified in point (d) of Article 15(2) and the deadband (threshold) is not higher than the value specified in that Article; and	-	
45	3	c	v	the insensitivity of active power frequency response at any relevant operating point does not exceed the requirements set out in point (d) of Article 15(2).	-	
45	4			With regard to the frequency restoration control test the following requirements shall apply:	-	
45	4	a		the power-generating module's technical capability to participate in frequency restoration control shall be demonstrated and the cooperation of FSM and frequency restoration control shall be checked;	-	
45	4	b		the test shall be deemed successful if the results, for both dynamic and static parameters, comply with the requirements of point (e) of Article 15(2).	-	
45	5			With regard to the black start capability test the following requirements shall apply:	Kun for anlæg der skal levere frekvensgenoprettelseskontrol.	
45	5	a		for power-generating modules with black start capability, this technical capability to start from shut down without any external electrical energy supply shall be demonstrated;	-	
45	5	b		the test shall be deemed successful if the start-up time is kept within the time frame set out in point (iii) of Article 15(5)(a).	-	
45	6			With regard to the tripping to houseload test the following requirements shall apply:	-	
45	6	a		the power-generating modules' technical capability to trip to and stably operate on house load shall be demonstrated;	-	
45	6	b		the test shall be carried out at the maximum capacity and nominal reactive power of the power-generating module before load shedding;	-	

45	6	c		the relevant system operator shall have the right to set additional conditions, taking into account point (c) of Article 15(5);	-	
45	6	d		the test shall be deemed successful if tripping to house load is successful, stable houseload operation has been demonstrated in the time period set out in point (c) of Article 15(5) and re-synchronisation to the network has been performed successfully.	-	
45	7			With regard to the reactive power capability test the following requirements shall apply:	-	
45	7	a		the power-generating module's technical capability to provide leading and lagging reactive power capability in accordance with points (b) and (c) of Article 18(2) shall be demonstrated;	-	
45	7	b		the test shall be deemed successful if the following conditions are fulfilled:	-	
45	7	b	i	the power-generating module operates at maximum reactive power for at least one hour, both leading and lagging, at: — minimum stable operating level, — maximum capacity, and — an active power operating point between those maximum and minimum levels;	-	
45	7	b	ii	the power-generating module's capability to change to any reactive power target value within the agreed or decided reactive power range shall be demonstrated.	-	
Compliance test for type D synchronous power-generating modules						
46	1			Type D synchronous power-generating modules are subject to the compliance tests for type B and C synchronous power-generating modules described in Articles 44 and 45.	-	
46	2			Instead of the relevant test, the power-generating facility owner may use equipment certificates issued by an authorised certifier to demonstrate compliance with the relevant requirement. In such a	-	

				case, the equipment certificates shall be provided to the relevant system operator.		
Compliance test for type B power park modules						
47	1			Power-generating facility owners shall undertake LFSM-O response compliance tests in relation to type B power park modules. Instead of the relevant test, the power-generating facility owner may use equipment certificates issued by an authorised certifier to demonstrate compliance with the relevant requirement. In that case, the equipment certificates shall be provided to the relevant system operator	-	
47	2			With regard to type B power park modules, the LFSM-O response tests shall reflect the choice of control scheme selected by the relevant system operator.	-	
47	3			With regard to the LFSM-O response tests the following requirements shall apply:	-	
47	3	a		the power park module's technical capability to continuously modulate active power to contribute to frequency control in case of increase of frequency in the system shall be demonstrated. The steady-state parameters of regulations, such as droop and deadband, and dynamic parameters shall be verified;	-	
47	3	b		the test shall be carried out by simulating frequency steps and ramps big enough to trigger at least 10 % of maximum capacity change in active power, taking into account the droop settings and the deadband. To perform this test simulated frequency deviation signals shall be injected simultaneously into the control system references;	-	
47	3	c		the test shall be deemed successful in the event that the test results, for both dynamic and static parameters, comply with the requirements set out in Article 13(2).	-	
Compliance tests for type C power park modules						

48	1			In addition to the compliance tests for type B power park modules described in Article 47, power-generating facility owners shall undertake the compliance tests set out in paragraphs 2 to 9 in relation to type C power park modules. Instead of the relevant test, the power-generating facility owner may use equipment certificates issued by an authorised certifier to demonstrate compliance with the relevant requirement. In such a case, the equipment certificate shall be provided to the relevant system operator.	-	
48	2			With regard to the active power controllability and control range test the following requirements shall apply:	-	
48	2	a		the power park module's technical capability to operate at a load level below the setpoint set by the relevant system operator or the relevant TSO shall be demonstrated;	-	
48	2	b		the test shall be deemed successful if the following conditions are fulfilled:	-	
48	2	b	i	the load level of the power park module is kept below the setpoint;	-	
48	2	b	ii	the setpoint is implemented according to the requirements laid down in Article 15(2)(a); and	-	
48	2	b	iii	the accuracy of the regulation complies with the value specified in point (a) of Article 15(2).	-	
48	3			With regard to the LFSM-U response test the following requirements shall apply:	-	
48	3	a		the power park module's technical capability to continuously modulate active power to contribute to frequency control in case of a large frequency drop in the system shall be demonstrated;	-	
48	3	b		the test shall be carried out by simulating the frequency steps and ramps big enough to trigger at least 10 % of maximum capacity active power change with a starting point of no more than 80 % of maximum capacity, taking into account the droop settings and the deadband;	-	

48	3	c		the test shall be deemed successful if the following conditions are fulfilled:	-	
48	4			With regard to the FSM response test the following requirements shall apply:	-	
48	4	a		the power park module's technical capability to continuously modulate active power over the full operating range between maximum capacity and minimum regulating level to contribute to frequency control shall be demonstrated. The steady-state parameters of regulations, such as insensitivity, droop, deadband and range of regulation, as well as dynamic parameters, including frequency step change response shall be verified;	-	
48	4	b		the test shall be carried out by simulating frequency steps and ramps big enough to trigger the whole active power frequency response range, taking into account the droop settings and the deadband. Simulated frequency deviation signals shall be injected to perform the test;	-	
48	4	c		the test shall be deemed successful if the following conditions are fulfilled:	-	
48	4	c	i	the activation time of the full active power frequency response range as a result of a frequency step change is no longer than that required by point (d) of Article 15(2);	-	
48	4	c	ii	undamped oscillations do not occur after the step change response;	-	
48	4	c	iii	the initial delay is in line with point (d) of Article 15(2);	-	
48	4	c	iv	the droop settings are available within the ranges specified in point (d) of Article 15(2) and the deadband (threshold) is not higher than the value chosen by the relevant TSO; and	-	
48	4	c	v	the insensitivity of active power frequency response does not exceed the requirement set out in point (d) of Article 15(2).	-	

48	5			With regard to the frequency restoration control test the following requirements shall apply:	Benyttes ikke I dansk kontekst.	
48	6			With regard to the reactive power capability test the following requirements shall apply:	-	
48	6	a		the power park module's technical capability to provide leading and lagging reactive power capability in accordance with points (b) and (c) of Article 21(3) shall be demonstrated;	-	
48	6	b		it shall be carried out at maximum reactive power, both leading and lagging, and shall verify the following parameters:	-	
48	6	b	i	operation in excess of 60 % of maximum capacity for 30 min;	-	
48	6	b	ii	operation within the range of 30-50 % of maximum capacity for 30 min; and	-	
48	6	b	iii	operation within the range of 10-20 % of maximum capacity for 60 min;	-	
48	6	c		the test shall be deemed successful if the following criteria are fulfilled:	-	
48	6	c	i	the power park module operates for a duration no shorter than the requested duration at maximum reactive power, both leading and lagging, in each parameter specified in paragraph 6(b);	-	
48	6	c	ii	the power park module's capability to change to any reactive power target value within the agreed or decided reactive power range is demonstrated; and	-	
48	6	c	iii	no protection action takes place within the operation limits specified by the reactive power capacity diagram.	-	
48	7			With regard to the voltage control mode test the following requirements shall apply:	-	
48	7	a		the power park module's capability to operate in voltage control mode referred to in the conditions set out in points (ii) to (iv) of Article 21(3)(d) shall be demonstrated;	-	

48	7	b		The voltage control mode test shall verify the following parameters:	-	
48	7	b	i	the implemented slope and deadband according to Article 21(3)(d)(iii);	-	
48	7	b	ii	the accuracy of the regulation;	-	
48	7	b	iii	the insensitivity of the regulation; and	-	
48	7	b	iv	the time of reactive power activation;	-	
48	7	c		The test shall be deemed successful if the following conditions are fulfilled:	-	
48	7	c	i	the range of regulation and adjustable droop and deadband complies with the agreed or decided characteristic parameters set out in point (d) of Article 21(3);	-	
48	7	c	ii	the insensitivity of voltage control is not higher than 0,01 pu, in accordance with point (d) of Article 21(3); and	-	
48	7	c	iii	following a step change in voltage, 90 % of the change in reactive power output has been achieved within the times and tolerances specified in point (d) of Article 21(3).	-	
48	8			With regard to the reactive power control mode test the following requirements shall apply:	-	
48	8	a		the power park module's capability to operate in reactive power control mode, in accordance with point (v) of Article 21(3)(d), shall be demonstrated;	-	
48	8	b		the reactive power control mode test shall be complementary to the reactive power capability test;	-	
48	8	c		the reactive power control mode test shall verify the following parameters:	-	
48	8	c	i	the reactive power setpoint range and increment;	-	
48	8	c	ii	the accuracy of the regulation; and	-	
48	8	c	iii	the time of reactive power activation	-	
48	8	d		the test shall be deemed successful if the following conditions are fulfilled:	-	

48	8	d	i	the reactive power setpoint range and increment are ensured in accordance with point (d) of Article 21(3); and	-	
48	8	d	ii	the accuracy of the regulation complies with the conditions set out in point (d) of Article 21(3).	-	
48	9			With regard to the power factor control mode test the following requirements shall apply:	-	
48	9	a		the power park module's capability to operate in power factor control mode in accordance with point (vi) of Article 21(3)(d) shall be demonstrated;	-	
48	9	b		the power factor control mode test shall verify the following parameters:	-	
48	9	b	i	the power factor setpoint range;	-	
48	9	b	ii	the accuracy of the regulation; and	-	
48	9	b	iii	the response of reactive power due to step change of active power;	-	
48	9	c		the test shall be deemed successful if the following conditions are cumulatively fulfilled:	-	
48	9	c	i	the power factor setpoint range and increment are ensured in accordance with point (d) of Article 21(3);	-	
48	9	c	ii	the time of reactive power activation as a result of step active power change does not exceed the requirement laid down in point (d) of Article 21(3); and	-	
48	9	c	iii	the accuracy of the regulation complies with the value specified in point (d) of Article 21(3).	-	
48	10			With regard to the tests referred to in paragraphs 7, 8 and 9, the relevant system operator may select only one of the three control options for testing.	-	
Compliance tests for type D power park modules						

49	1			Type D power park modules are subject to the compliance tests for type B and C power park modules in accordance with the conditions set out in Articles 47 and 48.	-	
49	2			Instead of the relevant test, the power-generating facility owner may use equipment certificates issued by an authorised certifier to demonstrate compliance with the relevant requirement. In that case, the equipment certificates shall be provided to the relevant system operator.	-	
Compliance simulations for type B synchronous power-generating modules						
51	1			Power-generating facility owners shall undertake LFSM-O response simulations in relation to type B synchronous power-generating modules. Instead of the relevant simulations, the power-generating facility owner may use equipment certificates issued by an authorised certifier to demonstrate compliance with the relevant requirement. In that case, the equipment certificates shall be provided to the relevant system operator	-	
51	2			With regard to the LFSM-O response simulation the following requirements shall apply:	-	
51	2	a		the power-generating module's capability to modulate active power at high frequency in accordance with Article 13(2) shall be demonstrated by simulation;	-	
51	2	b		the simulation shall be carried out by means of high frequency steps and ramps reaching minimum regulating level, taking into account the droop settings and the deadband;	-	
51	2	c		the simulation shall be deemed successful in the event that:	-	
51	2	c	i	the simulation model of the power-generating module is validated against the compliance test for LFSM-O response described in Article 44(2); and	-	

51	2	c	ii	compliance with the requirement set out in Article 13(2) is demonstrated.	-	
51	3			With regard to the simulation of fault-ride-through capability of type B synchronous power-generating modules, the following requirements shall apply:	-	
51	3	a		the power-generating module's capability to ride through faults in accordance with the conditions set out in subparagraph (a) of Article 14(3) shall be demonstrated by simulation;	-	
51	3	b		the simulation shall be deemed successful if compliance with the requirement set out in point (a) of Article 14(3) is demonstrated.	-	
51	4			With regard to the post fault active power recovery simulation the following requirements shall apply:	-	
51	4	a		the power-generating module's capability to provide post fault active power recovery referred to in the conditions set out in Article 17(3) shall be demonstrated;	-	
51	4	b		the simulation shall be deemed successful if compliance with the requirement set out in Article 17(3) is demonstrated.	-	
Compliance simulation for type C synchronous power-generating modules						
52	1			In addition to the compliance simulations for type B synchronous power-generating modules set out in Article 51, type C synchronous power-generating modules shall be subject to the compliance simulations detailed in paragraphs 2 to 5. Instead of all or part of those simulations, the power-generating facility owner may use equipment certificates issued by an authorised certifier, which must be provided to the relevant system operator.	-	
51	2			With regard to the LFSM-U response simulation the following requirements shall apply:	-	

51	2	a		the power-generating module's capability to modulate active power at low frequencies in accordance with point (c) of Article 15(2) shall be demonstrated;	-	
51	2	b		the simulation shall be carried out by means of low frequency steps and ramps reaching maximum capacity, taking into account the droop settings and the deadband;	-	
51	2	c		the simulation shall be deemed successful in the event that:	-	
51	2	c	i	the simulation model of the power-generating module is validated against the compliance test for LFSM-U response described in of Article 45(2); and	-	
51	2	c	ii	compliance with the requirement of point (c) of Article 15(2) is demonstrated.	-	
51	3			With regard to the FSM response simulation the following requirements shall apply:	-	
51	3	a		the power-generating module's capability to modulate active power over the full frequency range in accordance with point (d) of Article 15(2) shall be demonstrated;	-	
51	3	b		the simulation shall be carried out by simulating frequency steps and ramps big enough to trigger the whole active power frequency response range, taking into account the droop settings and the deadband;	-	
51	3	c		the simulation shall be deemed successful in the event that:	-	
51	3	c	i	the simulation model of the power-generating module is validated against the compliance test for FSM response described in Article 45(3); and	-	
51	3	c	ii	compliance with the requirement of point (d) of Article 15(2) is demonstrated.	-	
51	4			With regard to the island operation simulation the following requirements shall apply:	Drift ved net i ø-drift er ikke tilladt, derfor er der ikke behov for simuleringen.	

51	5			With regard to the reactive power capability simulation the following requirements shall apply:	-	
51	5	a		the power-generating module's capability to provide leading and lagging reactive power capability in accordance with the conditions set out in points (b) and (c) of Article 18(2) shall be demonstrated;	-	
51	5	b		the simulation shall be deemed successful if the following conditions are fulfilled:	-	
51	5	b	i	the simulation model of the power-generating module is validated against the compliance tests for reactive power capability described in Article 45(7); and	-	
51	5	b	ii	compliance with the requirements of points (b) and (c) of Article 18(2) is demonstrated.	-	
Compliance simulations for type D synchronous power-generating modules						
52	1			In addition to the compliance simulations for type B and C synchronous power-generating modules set out in Articles 51 and 52, except for the simulation of fault-ride-through capability of type B synchronous power-generating modules referred to in Article 51(3), type D synchronous power-generating modules are subject to the compliance simulations set out in paragraphs 2 and 3. Instead of all or part of those simulations, the power-generating facility owner may use equipment certificates issued by an authorised certifier, which must be provided to the relevant system operator.	-	
51	2			With regard to the power oscillations damping control simulation the following requirements shall apply:	-	
51	2	a		it shall be demonstrated that the power-generating module's performance in terms of its control system (‘PSS function’) is capable of damping active power oscillations in accordance with the conditions set out in paragraph 2 of Article 19;	-	

51	2	b		the tuning must result in improved damping of corresponding active power response of the AVR in combination with the PSS function, compared to the active power response of the AVR alone;	-	
51	2	c		the simulation shall be deemed successful if the following conditions are cumulatively fulfilled:	-	
51	2	c	i	the PSS function damps the existing active power oscillations of the power-generating module within a frequency range specified by the relevant TSO. That frequency range shall include the local mode frequencies of the power-generating module and the expected network oscillations; and	-	
51	2	c	ii	a sudden load reduction of the power-generating module from 1 pu to 0,6 pu of the maximum capacity does not lead to undamped oscillations in active or reactive power of the power-generating module.	-	
51	3			With regard to the simulation of fault-ride-through capability of type D synchronous power-generating modules, the following requirements shall apply:	-	
51	3	a		the power-generating module's capability to provide fault-ride-through in accordance with the conditions set out in point (a) of Article 16(3) shall be demonstrated;	-	
51	3	b		the simulation shall be deemed successful if compliance with the requirement laid down in point (a) of Article 16(3) is demonstrated.	-	
Compliance simulations for type B power park modules						
52	1			Type B power park modules are subject to the compliance simulations in paragraphs 2 to 5. Instead of all or part of those simulations, the power-generating facility owner may use equipment certificates issued by an authorised certifier, which must be provided to the relevant system operator	-	

51	2			With regard to the LFSM-O response simulation the following requirements shall apply:	-	
51	2	a		the power park module's capability to modulate active power at high frequency in accordance with Article 13(2) shall be demonstrated;	-	
51	2	b		the simulation shall be carried out by means of high frequency steps and ramps reaching minimum regulating level, taking into account the droop settings and the deadband;	-	
51	2	c		the simulation shall be deemed successful in the event that:	-	
51	2	c	i	the simulation model of the power park module is validated against the compliance test for LFSM-O response set out in Article 47(3); and	-	
51	2	c	ii	compliance with the requirement laid down in Article 13(2) is demonstrated.	-	
51	3			With regard to the fast fault current injection simulation the following requirements shall apply:	-	
51	3	a		the power park module's capability to provide fast fault current injection in accordance with the conditions set out in point (b) of Article 20(2) shall be demonstrated;	-	
51	3	b		the simulation shall be deemed successful if compliance with the requirement laid down in point (b) of Article 20(2) is demonstrated.	-	
51	4			With regard to the fault-ride-through simulation capability of type B power park modules, the following requirements shall apply:	-	
51	4	a		the power park module's capability to ride through faults in accordance with the conditions set out in point (a) of Article 14(3) shall be demonstrated by simulation;	-	
51	4	b		the simulation shall be deemed successful if compliance with the requirement laid down in point (a) of Article 14(3) is demonstrated.	-	
51	5			The following requirements with regard to the post fault active power recovery simulation shall apply:	-	

51	5	a		the power park module's capability to provide post fault active power recovery in accordance with the conditions set out in Article 20(3) shall be demonstrated;	-	
51	5	b		the simulation shall be deemed successful if compliance with the requirement laid down in Article 20(3) is demonstrated.	-	
Compliance simulations for type C power park modules						
55	1			In addition to the compliance simulations for type B power park modules set out in Article 54, type C power park modules are subject to the compliance simulations set out in paragraphs 2 to 7. Instead of all or part of those simulations, the power-generating facility owner may use equipment certificates issued by an authorised certifier, which must be provided to the relevant system operator.	-	
55	2			With regard to the LFSM-U response simulation the following requirements shall apply:	-	
55	2	a		the power park module's capability to modulate active power at low frequencies in accordance with point (c) of Article 15(2) shall be demonstrated;	-	
55	2	b		the simulation shall be carried out by simulating low frequency steps and ramps reaching maximum capacity, taking into account the droop settings and the deadband;	-	
55	2	c		the simulation shall be deemed successful in the event that:	-	
55	2	c	i	the simulation model of the power park module is validated against the compliance test for LFSM-U response set out in Article 48(3); and	-	
55	2	c	ii	compliance with the requirement laid down in point (c) of Article 15(2) is demonstrated.	-	
55	3			With regard to the FSM response simulation the following requirements shall apply:	-	

55	3	a		the power park module's capability to modulate active power over the full frequency range as referred to in point (d) of Article 15(2) shall be demonstrated;	-	
55	3	b		the simulation shall be carried out by simulating frequency steps and ramps big enough to trigger the whole active power frequency response range, taking into account the droop settings and the deadband	-	
55	3	c		the simulation shall be deemed successful in the event that:	-	
55	3	c	i	the simulation model of the power park module is validated against the compliance test for FSM response set out in Article 48(4); and	-	
55	3	c	ii	compliance with the requirement laid down in point (d) of Article 15(2) is demonstrated.	-	
55	4			With regard to the island operation simulation, the following requirements shall apply:	Ikke krav til Ø-drift på distributionsnettet.	
55	5			With regard to the simulation of the capability of providing synthetic inertia, the following requirements shall apply:	Ikke krav til syntetisk inerti.	
55	6			With regard to the reactive power capability simulation, the following requirements shall apply:	-	
55	6	a		the power park module shall demonstrate that it can provide leading and lagging reactive power capability as set out in points (b) and (c) of Article 21(3);	-	
55	6	b		the simulation shall be deemed successful if the following conditions are cumulatively fulfilled:	-	
55	6	b	i	the simulation model of the power park module is validated against the compliance tests for reactive power capability set out in paragraph 6 of Article 48; and	-	
55	6	b	ii	compliance with the requirements laid down in points (b) and (c) of Article 21(3) is demonstrated.	-	

55	7			With regard to the power oscillations damping control simulation, the following requirements shall apply:	Ikke krav til effekt svingningsdæmpning i dag.	
Compliance simulations for type D power park modules						
56	1			In addition to the compliance simulations for type B and C power park modules set out in Articles 54 and 55, except for the fault-ride-through capability of type B power park modules referred to in Article 54(4), type D power park modules are subject to the fault-ride-through capability of power park modules compliance simulation.	-	
56	2			Instead of all or part of the simulations mentioned in paragraph 1, the power-generating facility owner may use equipment certificates issued by an authorised certifier, which must be provided to the relevant system operator	-	
56	3			The model of the power park module shall demonstrate that it is suitable for simulating the fault-ride-through capability in accordance with point (a) of Article 16(3).	-	
56	4			The simulation shall be deemed successful if the model demonstrates compliance with the conditions set out in point (a) of Article 16(3).	-	

Note til artikel 19, stk. 2, litra a):

Parameter og indstillinger af komponenter til spændingsregulering aftales og defineres med udgangspunkt i en specifik analyse.

Magnetiseringssystem

Et synkront produktionsanlæg skal være udstyret med et kontinuert fungerende magnetiseringssystem. Formålet er at sikre stabil drift af anlægget, samt give mulighed for at bidrage til regulering af spænding og/eller den reaktive effektbalance i det kollektive elforsyningsnet.

Magnetiseringssystemet skal konstrueres i overensstemmelse med den europæiske standard DS/EN 60034-16-1:2011 ”Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Chapter 1: Definitions”, og DS/CLSC/TR 60034-16-3:2004 ”Rotating electrical machines – Part 16: Excitation systems for synchronous machines – Section 3: Dynamic performance”.

I tilfælde af netforstyrrelser der medfører spændingsreduktion, skal generatoren i mindst 10 sekunder kunne overmagnetiseres 1,6 gange magnetiseringsstrøm og -spænding ved nominel effekt og tgφ = 0,4 i POC og nominel driftsspænding. Hvis overmagnetiseringsegenskaben afhænger af spændingen i POC, skal den nævnte egenskab være tilgængelig ved reduceret netspænding i POC ned til 0,6 p.u.

Generatorens overmagnetiseringsbeskyttelse og anden beskyttelse skal konstrueres og indstilles, så generatorens evne til midlertidig overbelastning kan udnyttes uden at overskride generatorens termiske grænser.

Magnetiseringssystemets begrænserfunktioner skal være selektive med anlæggets beskyttelsesfunktioner, og derved muliggøre kortvarig udnyttelse af overbelastningsegenskaber uden udkobling af anlægget.

Magnetiseringssystemets tidsrespons (målt på generatorklemmerne) under tomgang (generatoren er frakoblet nettet og drevet ved nominel omløbshastighed) ved en momentan 10 % ændring af referencespændingen skal være ikke-oscillerende, og have en stigetid (”rise-time”), som defineret i DS/EN 60034-16-3, på maksimalt 0,3 sekund for et statisk magnetiseringssystem. For et roterende magnetiseringssystem (”rotating exciter”) tillades et tidsrespons på maksimal 0,5 sekund ved en positiv ændring af referencespændingen og tilsvarende maksimalt 0,8 sekund ved en negativ 10 % ændring af referencespændingen.

Magnetiseringssystemets oversving (”overshoot”) målt på generator klemmerne, som defineret i DS/EN 60034-16-3, ved en momentan 10 % ændring i referencespændingen, må maksimalt være 15 % af ændringen.

Verifikationskrav magnetiseringssystem
Verifikationskrav af ovenstående funktionskrav til magnetiseringsudstyret skal vedlægges som dokumentation. Udførte simuleringer, relevant målinger fra idriftsættelsestest, funktionsbeskrivelser samt ”as build” indstillingsværdier skal vedlægges som en del af den samlede anlægsdokumentation.

Koordinering mellem begrænserfunktioner og beskyttelsesfunktioner dokumenteres ved et P/Q-diagram for hhv. statisk og dynamisk karakteristik, indeholdende funktionstider og aktiveringsniveauer.

Simulering, analyse og idriftsættelsestest skal anvendes til at dokumentere, at magnetiseringssystemet har tilfredsstillende dynamiske egenskaber.

De udførte simuleringer skal omfatte nedenstående testscenarier:

1. RMS-simulering af spændingsdyk i henhold til nedstående funktion, hvor maskinens før fejl driftspunkt er defineret ved UPOC = 1 p.u., P = 1 p.u., QPOC = 0,4 p.u.:
    a. $U_{poc}(t) = \begin{cases} 1\ p.u.\ hvor\ t < 0\ s \\ 0{,}6\ p.u.\ hvor\ t > 0\ s \end{cases}$

b. RMS-simulering af stepresponstest ved en momentan +/- 10 % ændring af referencespændingen, hvor maskinen drives i tomgang ved nominel omløbshatighed.

Den udførte idriftsættelsestest skal indeholde nedenstående tests:

1. Stepresponstest ved en momentan +/- 10 % ændring af referencespændingen, hvor maskinen drives i tomgang og ved nominel omløbshastighed.
2. Test af selektivitet mellem undermagnetiseringsbeskyttelse og undermagnetiseringsbegrænser. Dette udføres ved:
    a. Stepresponstest, hvor maskinen forsøges tvunget i et undermagnetiseret arbejdspunkt, som ligger uden for det tilladelige arbejdsområde for undermagnetiseringsbegrænser.
    b. Oprampning af aktiv effekt, fra Pmin til Pn, hvor maskinen, inden påbegyndelse af test, ligges i et fuld undermagnetiseret arbejdspunkt.
3. Test af selektivitet mellem overmagnetiseringsbeskyttelse og overmagnetiseringsbegrænseren. Dette udføres ved:
    a. Stepresponstest, hvor maskinen forsøges tvunget i et overmagnetiseret arbejdspunkt, som ligger uden for det tilladelige arbejdsområde for overmagnetiseringsbegrænseren.
    b. Oprampning af aktiv effekt, fra Pmin til Pn, hvor maskinen, inden påbegyndelser af test, ligges i et fuldt overmagnetiseret arbejdspunkt.
4. Test af statorstrømbegrænsers performance. Dette udføres ved:
    a. Stepresponstest, hvor maskinen forsøges tvunget i et arbejdspunkt, som ligger uden for den tilladelige strømværdi for statorstrømbegrænser. Testen udføres ved reduceret indstillinger.
5. Test af V/Hz-begrænsers performance. Dette udføres ves:
    a. Stepresponstest, hvor maskinen forsøges tvunget i et arbejdspunkt, som ligger uden for det tilladelige forhold mellem spænding og frekvens for V/Hz-begrænser. Testen udføres ved reduceret indstillinger og hvor maskinen drives i tomgang og ved nominel omløbshastighed.
    b. Ændring af omløbshastighed, hvor maskinen forsøges tvunget i et arbejdspunkt, som ligger uden for det tilladelige forhold mellem spænding og frekvens for V/Hz-begrænser. Testen udføres ved reduceret indstillinger og hvor maskinen drives i tomgang og ved nominel omløbshastighed før ændringen af omløbshastighed.

PSS-funktion

PSS-funktionen skal anvende input fra både rotorhastighed/netfrekvens og aktiv effekt (dual input) til at udlede stabilitetssignalet, hvor en dæmpetilsats af typen IEEE PSS2B, jf. IEEE 421.5 er normgivende.

Justering af PSS-funktionen skal være således, at der opnås en positiv dæpning i frekvensområdet 0,2 Hz til 0,7 Hz.

Fasen af det tilførte dæmpningssignal som produceres af PSS-funktionen skal i frekvensområdet 0,2 til 2 Hz være i fase med hastighedsændringen for generatorens rotor, afvigelser på op til -30 grader (underkompenseret) kan accepteres.

Dæmpning af anlæggets effektoscillationer (eksponentielt aftagende funktion) skal ved alle arbejdspunkter, og ved enhver forstyrrelse med PSS-funktionen aktiveret, være hurtigere end 1 sekund.

Anlæggets naturlige dæmpning af "local mode" effektoscillationer må ikke påvirkes negativt af PSS-funktionen.

Justering af PSS-funktionen skal være således, at ændringer af anlæggets arbejdspunkt (aktiv effekt) under normal drift, eller ved en fejl i fx turbineregulator, kedelanlæg, fødevandsanlæg eller andre hjælpekraftsanlæg, ikke må medføre, at spændingen på højspændingssiden af anlæggets maskintransformer ændres mere end 1 %.

PSS-udgangssignalet skal begrænses, således at aktivering af PSS-funktionen ikke medfører en ændring af generatorspændingen større end +/- 5 % af generatorens nominelle spænding. Det er tilladt, at grænserne reduceres automatisk og dynamisk af spændingsregulatoren, fx ved aktivering af magnetiseringssystemets begrænserfunktioner.

PSS-funktionen skal deaktiveres automatisk, når den producerede aktive effekter mindre end 20 % af nominel effekt.
Det skal være muligt at ind- og udkoble PSS-funktionen. Ved udkobling af PSS-funktionen skal der afgives en alarm.

Verifikationskrav PSS-funktion
Overholdelse af ovenstående funktionskrav til PSS-funktionen skal vedlægges som dokumentation. Udførte simuleringer, relevante målinger fra idriftsættelsestest, funktionsbeskrivelser samt "as build" indstillingsværdier skal vedlægges som en del af den samlede anlægsdokumentation.

Simulering, analyse og idriftsættelsestest skal anvendes til at dokumentere, at de anvendte indstillingsværdier giver PSS-funktionen og det samlede magnetiseringssystem tilfredsstillende dynamiske egenskaber.

De udførte simuleringer skal omfatte nedenstående testscenarier, hvor disse, med undtagelse af Test 5, skal simuleres med PSS-funktionen aktiveret henholdsvis deaktiveret:

1. Verifikation af frekvenskarakteristikken, herunder korrekt fasekompensering af det samlede magnetiseringsanlæg, i form af Bode plots for forstærkning af fase.
2. Steprespons ved en momentan +/- 5 % ændring af referencespændingen. Simuleringer gennemføres for forskellige arbejdspunkter, fx 25 %, 50 %, 75 % og 100 % af anlæggets nominelle effekt.
3. Generatornær kortslutning
4. Udkobling af en linje, hvor ændringen i det kollektive elforsyningsnet, går fra stærkeste- til svageste netkonfiguration (kortslutningseffekt). Simuleringer gennemføres for forskellige arbejdspunkter, fx 25 %, 50 %, 75 % og 100 % af anlæggets nominelle effekt.
5. Ændring af generatorens tilførte mekaniske effekt fra drivmaskinen i henholdende til nedstående funktioner (PSS-enhed skal være aktiv):
    a. Sinusfunktion, $p(t) = A \cdot Sin(\omega \cdot t), A = 0{,}1\ p.u., \omega = 2 \cdot \pi \cdot \frac{1}{60} rad$
    b. Rampefunktion, $p(t) = \begin{cases} 0\ p.u. hvor\ t < 0s \\ 0{,}25 \cdot t\ p.u. hvor\ 0\,\text{sec} < t \leq 4\ s \\ 1\ p.u. hvor\ t > 4\ s \end{cases}$

c. Stepfunktion, $p(t) = \begin{cases} 1\ p.u. hvor\ t < 0\ s \\ 0{,}6\ p.u. hvor\ t > 0\ s \end{cases}$

Den udførte idriftsættelsestest skal indeholde nedenstående tests:

1. Måling af fase og forstærkning (bode plot) for overføringsfunktionen Vt(s)/Vref(s) med PSS-funktionen deaktiveret og anlægget drevet "off-grid", ved nominel omløbshastighed og -terminalspænding
2. Måling af fase og forstærkning (bode plot) for overføringsfunktionen Vt(s)/Vref(s) med PSS-funktionen deaktiveret og anlægget drevet "on-grid", ved et driftspunkt så tæt på P = 0 og Q = 0, som muligt.
3. Måling af overføringsfunktion for PSS-funktionen.
4. Stepresponstest ved en momentan +/- 5 % ændring af referencespændingen. Testen gennemføres for forskellige arbejdspunkter, fx 25 %, 50 %, 75 % og 100 % af anlæggets nominelle effekt med PSS-funktionen aktiveret henholdsvis deaktiveret.
5. Forøgelse af PSS-forstærkning med en faktor 3 af den foreslåede værdi.