SISTEMAS ENERGÉTICOS SATURNO SLU

ANEXOS TOMO I

MODIFICADO AL PROYECTO PARQUE EÓLICO “MORTERUELO”

T.M. DE PANCRUDO (TERUEL)

Marzo 2023

ÍNDICE

1. ANEXO I DOCUMENTACIÓN REQUERIDA POR EL DEPARTAMENTO DE ECONOMÍA, INDUSTRIA Y EMPLEO DEL GOBIERNO DE ARAGÓN DECRETO-LEY 2/2016, DE 30 DE AGOSTO, DE MEDIDAS URGENTES PARA LA EJECUCIÓN DE LAS SENTENCIAS DICTADAS EN RELACIÓN CON LOS CONCURSOS CONVOCADOS EN EL MARCO DEL DECRETO 124/2010, DE 22 DE JUNIO, Y EL IMPULSO DE LA PRODUCCIÓN DE ENERGÍA ELÉCTRICA A PARTIR DE LA ENERGÍA EÓLICA EN ARAGÓN. ARTÍCULO 13 APARTADO C)

1.1. Razones de cualquier índole que justifiquen la implantación o modificación del parque eólico en la zona de que se trate.

1 Obtener energía partiendo de recursos no contaminantes sin emisión de gases que contribuyen a aumentar el efecto invernadero, especialmente CO_2.

2 Potenciar el uso de energías renovables obteniendo una mejora en el medioambiente y a su vez repercusiones positivas en el ámbito socioeconómico

3 Esta iniciativa privada de aprovechamiento de la energía eólica repercutirá directamente sobre la estructura productiva de la zona y generará unos ingresos por canon de cesión de terrenos, licencia de obras, contratación de personal e ingresos de carácter fiscal y administrativos importantes.

4 Las instalaciones mejorarán las infraestructuras de regionales energéticas.

5 El carácter inagotable de la energía eólica y su utilización que es independiente de cualquier relación comercial, hace que el desarrollo de este parque y sus infraestructuras ofrezcan un aprovechamiento óptimo de un de lo recursos naturales propios de Aragón como es el viento.

6 Contribución en la disminución de la dependencia energética de nuestro país así como de la Unión Europea.

1.2. Criterios técnicos de situación que desde el punto de vista de aprovechamiento del recurso eólico, optimización de la planificación de redes de evacuación y transporte eléctrico, respecto al patrimonio cultural y a los valores medioambientales se han seguido para elegir los terrenos en los que se situarán concretamente las instalaciones.

La zona en la que se sitúa el parque ya ha sido estudiada por el SIEMENS GAMESA y por otros promotores, y se han construido parques eólicos que fueron tramitados por el promotor ante la Administración.

1.3. Descripción de los recursos eólicos presentes mediante las mediciones efectuadas o un estudio o modelización que confirme la existencia de recurso suficiente para el funcionamiento del parque.

Ver estudio de viento incluido en el volumen ANEXOS TOMO II

1.4. Adecuación del proyecto a la situación de planeamiento urbanístico vigente, en el área de implantación prevista.

AYUNTAMIENTO DE PANCRUDO.- Teruel

José Antonio Rallego Escriche (1 de 1)
Secretario-Interventor
Fecha Firma: 17/11/2020
HASH: d13192b7ea4d0e4530b71d11161321d8

INFORME DE COMPATIBILIDAD URBANÍSTICA.

A la vista de la solicitud presentada por:

Nombre y Apellidos/Razón Social	NIF/CIF
SIEMENS GAMESA RENOVABLES ENERGY WIND FARMS, S.A.	ESA80477144

Examinada la documentación que le acompaña en relación con la solicitud de Informe de compatibilidad urbanística de las instalaciones en las que habrá de desarrollarse la siguiente actividad: PARQUE EÓLICO MORTERUELO.

Se emite el siguiente,

INFORME

PRIMERO. El planeamiento urbanístico que resulta aplicable a las parcelas es:

—Programa de Coordinación del Planeamiento Urbanístico de los municipios pertenecientes a la Mancomunidad del Altiplano de Teruel.

SEGUNDO. Según el planeamiento el suelo en que está ubicado el parque eólico está clasificado como suelo no urbanizable y su categoría es genérico.

En conclusión a lo expuesto informo sobre la compatibilidad urbanística de la construcción del parque eólico MORTERUELO de las instalaciones en las que habrá de desarrollarse la actividad descrita.

DOCUMENTO FIRMADO ELECTRÓNICAMENTE

Cód. Validación: 7CTJXAWAQ39EINVPJE7PMTT5F | Verificación: https://pancrudo.sedelectronica.es/
Documento firmado electrónicamente desde la plataforma esPublico Gestiona | Página 1 de 1

1.5. Descripción y justificación de los datos referidos a la ordenación del parque eólico, tales como superficie, ocupación de la finca por edificaciones, instalaciones y superficies pavimentadas. Se incluirá asimismo, la justificación de los movimientos de tierra a efectuar.

Tabla resumen de las afecciones del Parque Eólico (incluida en la Memoria del proyecto)

			Superficie
Ocupación aerogeneradores			1.283 m2
Ocupación plataformas			20.845 m2
Ocupación caminos	Existentes	48,32%	17.696 m2
	Nuevos	51,68%	18.927 m2
	Total caminos		36.623 m2
Ocupación total			58.751 m2
Longitud Caminos	Existentes	48,33%	1.521 m
	Nuevos	51,67%	1.626 m
	Total caminos		3.148 m
Ocupación de las losas de cimentación de los aerogeneradores			
Ocupación aerogeneradores (Losa de cimentación)			1.140 m2

En el anexo de cálculos de la memoria del proyecto se han colocado las tablas con los movimientos de tierra a realizar en Caminos, Cimentaciones y Plataformas de Montaje.

En los planos 07 de perfiles longitudinales se puede observar cómo se han trazado los caminos para ajustar sus características de diseño a los condicionantes de los transportes y de las grúas de montaje, el resultado de los movimientos de tierras expresado en las tablas es consecuencia de adaptar los caminos a esos condicionantes.

En el Anexo de cálculos se incluye también una tabla con la superficie de los taludes para replantar con tierra vegetal procedente de los desbroces.

1.6. Descripción de los servicios existentes y previstos relativos a accesos, abastecimientos, energías, alumbrado y otras instalaciones.

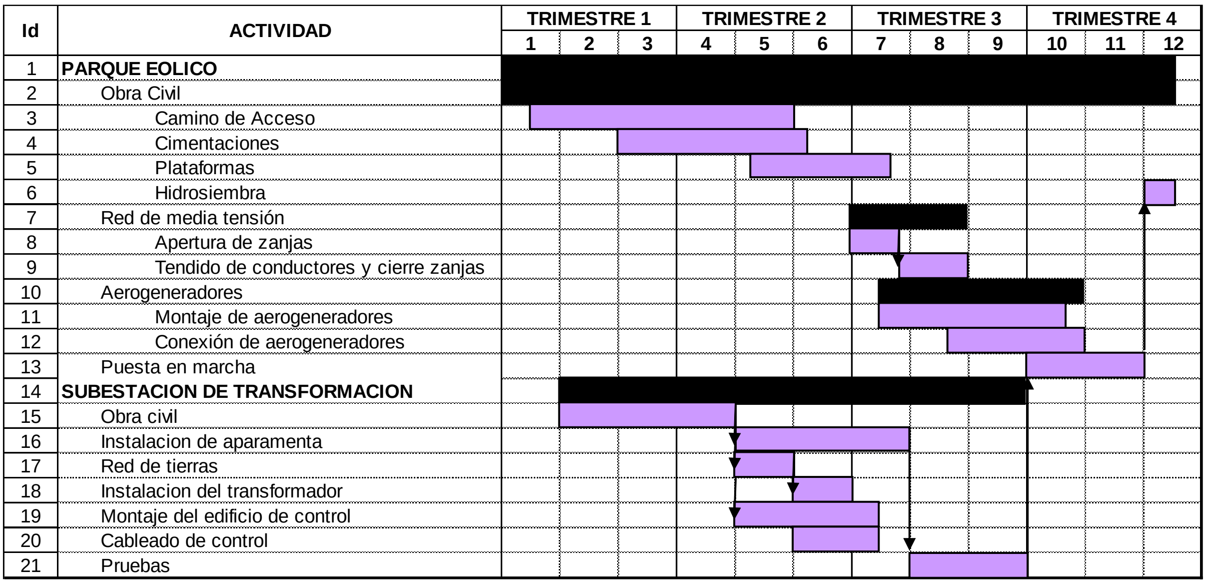
Los viales de acceso al parque eólico son de nueva creación, adaptando los caminos rurales existentes y construyendo los necesarios para accedes a los aerogeneradores.

1.7. Descripción de las características formales y constructivas; uso y destino de las edificaciones, referidas a la superficie construida; altura de las edificaciones y de los elementos singulares, composición, materiales y otras.

El uso y destino tanto de las edificaciones como los elementos singulares de este proyecto, son la generación de energía eléctrica a partir del viento.

En el parque eólico, los elementos singulares a instalar son los aerogeneradores. En la memoria del proyecto y en el ANEXO II, se detalla su altura, composición y materiales.

1.8. Plazo de ejecución del proyecto.



1.9. Presupuesto de las instalaciones.

Ver presupuesto en los documentos de Proyecto

1.10. Descripción detallada de todas las instalaciones de alta y baja tensión con adecuación a la Normativa Vigente.

El proyecto presentado visado por técnico competente y visado por el colegio oficial, cumple con los requisitos establecidos en el artículo 12 e Instrucción Técnica Complementaria ITC-RAT20, del vigente Reglamento sobre Condiciones Técnicas y Garantías de Seguridad en Centrales Eléctricas, Subestaciones y Centros de Transformación (aprobadas mediante Real Decreto 337/2014, de 9 de mayo, por el que se aprueban el Reglamento sobre condiciones técnicas y garantías de seguridad en instalaciones eléctricas de alta tensión y sus Instrucciones Técnicas Complementarias ITC-RAT 01 a 23.)

Ver Capitulo 1.3 de la memoria del proyecto

1.11. Descripción de las instalaciones de evacuación de energía eléctrica hasta el punto de conexión con la red de distribución o transporte.

En la memoria del proyecto y en el anexo de cálculos se describen las instalaciones tanto de obra civil como de obra eléctrica, hasta el centro de seccionamiento

La tramitación de la línea aérea de evacuación a 220kV hasta SET Valdeconejos y de la subestación de transformación común, se han realizado de forma independiente al proyecto del parque eólico. Las modificaciones de estas instalaciones que deriven del proyecto del parque eólico y viceversa, se tramitarán en sus respectivos expedientes administrativos.

1.12. Medidas previstas de protección contra incendios.

AEROGENERADORES

Esta instalación no está incluida dentro del ámbito de aplicación del real Decreto 2267/2004 de 3 de Diciembre por el que se aprueba el reglamento de seguridad contra incendios en los establecimientos industriales. Según se deduce del artículo 2 del citado Real Decreto y del articulo 3.1 de la Ley 21/1992 de 16 de Julio de Industria.

En la memoria se ha especificado que cada aerogenerador dispondrá de un extintor contra incendios, clase B29 en la zona de celdas. Es tos extintores cumplirán con lo indicado en la MIE RAT 14 capitulo 4, por ser los transformadores de aislamiento seco, no es necesario un sistema de extinción fijo.

Como en cualquier instalación existe un riesgo de incendio (calentamiento excesivo de la multiplicadora, del los sistemas hidráulicos etc). Los sistemas de detección de incendios instalados en el aerogenerador están conectados al SCADA del parque, por lo que garantiza la rápida actuación ante cualquier incidente.

El hecho que el sistema de generación se encuentre situado a una considerable altura del suelo permite que el incendio quede bastante aislado, con lo que se minimiza el riesgo de propagación del mismo a otras partes de la instalación.

Existe el riesgo de que se produzca un incendio cuando el personal de mantenimiento se encuentre dentro de la nacelle por lo que cada operado deberá de disponer de un sistema paracaídas que permita una rápida evacuación del aerogenerador en el caso de que se produzca un incendio incontrolado que bloquee el acceso a la escalera de la torre y sea necesario escapar por la otras salidas que dispone el aerogenerador.

El personal Operación Mantenimiento y Servicio de SIEMENS GAMESA, está entrenado para realizar esta evacuación de emergencia.

Queda totalmente prohibido el acceso de ninguna persona a la zona de altura del aerogenerador, si no va acompañado de un técnico cualificado de la compañía y deberá contar con los mismos equipos de protección y evacuación que el personal de la compañía, así como estar en posesión y en vigor, de la certificación necesaria para acceder a lo alto de un aerogenerador.

1.13. Descripción del aerogenerador a instalar que certifique el cumplimiento de las exigencias del operador del sistema conforme a la normativa estatal vigente y principales características, en especial, el apartado relativo a los huecos de tensión. Declaración de conformidad CE de las máquinas que se pretende instalar, junto con una descripción detallada del aerogenerador a instalar.

VER MEMORIA DEL PROYECTO Y ANEXO II

1.14. Adecuación de las instalaciones a las disposiciones relativas a la seguridad y a la salud para la utilización por los operadores de los equipos de trabajo.

A partir del estudio de seguridad y salud del proyecto, el contratista de la obras elaborará un Plan de Seguridad, previo al inicio de los trabajos Este plan será supervisado y aprobado por el coordinador de seguridad y salud que asuma los trabajos.

1.15. Estudio de seguridad y salud

Ver Estudio de Seguridad y Salud en los documentos de proyecto.

1.16. Relación de personas físicas y jurídicas propietarios de bienes, instalaciones, obras o servicios afectados por la instalación.

Nº FINCA PROYECTO	DATOS DE LA FINCA					AFECCIÓN								
						AEROGENERADOR				LÍNEA SUBTERRÁNEA			CAMINOS	
	PGNO	PARC	REF CATASTRAL	TM	SUPERFICIE PARCELA (m2)	Aero	VUELO (m2)	ZAPATA (m2)	Plataforma (m2)	Long. (m)	Superficie Permanente (m2)	Superficie Temporal (m2)	Long. (m)	Superficie (m2)
105	8	8	44186A00800008	Pancrudo	11.428,58		0,00	0,00	0,00	0,00	0,00	0,00	2.313,99	1.352,29
106	8	10	44186A00800010	Pancrudo	12.557,33		0,00	0,00	0,00	0,00	0,00	0,00	621,51	446,81
107	8	11	44186A00800011	Pancrudo	2.543,04		0,00	0,00	0,00	0,00	0,00	0,00	211,38	130,22
108	8	12	44186A00800012	Pancrudo	18.423,68		0,00	0,00	0,00	0,00	0,00	0,00	38,70	33,58
101	8	42	44186A00800042	Pancrudo	94.316,68		0,00	0,00	0,00	0,00	0,00	0,00	2.313,52	2.337,82
100	8	43	44186A00800043	Pancrudo	24.235,77		0,00	0,00	0,00	0,00	0,00	0,00	0,00	75,21
97	8	44	44186A00800044	Pancrudo	1.863,06		0,00	0,00	0,00	0,00	0,00	0,00	729,35	662,70
5	8	49	44186A00800049	Pancrudo	4.170,16		0,00	0,00	0,00	470,50	84,81	123,15	346,04	485,07
4	8	50	44186A00800050	Pancrudo	19.840,02		0,00	0,00	138,04	1.562,30	448,72	405,06	993,19	1.399,16
6	8	53	44186A00800053	Pancrudo	4.301,00		0,00	0,00	0,00	0,00	24,99	0,00	1.284,28	1.112,27
60	8	65	44186A00800065	Pancrudo	54.737,53		0,00	0,00	0,00	0,00	0,00	157,01	0,00	0,00
1	8	66	44186A00800066	Pancrudo	24.464,26	MO-01	1.234,18	0,00	0,00	0,00	0,00	89,38	0,00	0,00
1333	8	67	44186A00800067	Pancrudo	368.438,08		0,00	0,00	0,00	1.037,60	261,68	378,27	289,79	267,95
11	8	68	44186A00800068	Pancrudo	15.335,90		0,00	0,00	0,00	0,00	0,00	75,73	0,00	0,00
0	8	74	44186A00800074	Pancrudo	18.595,97		0,00	0,00	0,00	0,00	0,01	10,74	0,00	0,00
12b	8	75	44186A00800075	Pancrudo	376,87		0,00	0,00	0,00	6,10	0,67	11,10	0,00	0,00
22	8	99	44186A00800099	Pancrudo	19.719,32		0,00	0,00	0,00	776,10	77,56	388,09	0,00	0,00
25	8	103	44186A00800103	Pancrudo	12.410,07		0,00	0,00	0,00	114,50	11,44	57,27	0,00	0,00
21	8	109	44186A00800109	Pancrudo	367.323,25		0,00	0,00	0,00	1.881,30	188,09	940,14	0,00	0,00
18	8	116	44186A00800116	Pancrudo	444,00		0,00	0,00	0,00	114,30	11,41	63,46	0,00	0,00
65	8	120	44186A00800120	Pancrudo	12.792,58		0,00	0,00	0,00	0,00	0,00	49,10	0,00	0,00
63	8	123	44186A00800123	Pancrudo	1.682,74		0,00	0,00	0,00	10,30	0,99	38,44	0,00	0,00
61	8	124	44186A00800124	Pancrudo	6.673,59		0,00	0,00	0,00	139,60	13,90	76,23	0,00	0,00
0	8	125	44186A00800125	Pancrudo	46.210,06		0,00	0,00	0,00	749,30	74,97	336,60	0,00	0,00
64	8	126	44186A00800126	Pancrudo	13.959,97		0,00	0,00	0,00	639,40	63,94	287,07	0,00	0,00
71	8	181	44186A00800181	Pancrudo	30.062,74	MO-02	6.436,57	0,00	0,00	0,00	0,00	0,00	0,00	93,37
69	8	185	44186A00800185	Pancrudo	11.079,01		0,00	0,00	0,00	700,70	70,02	306,76	0,00	218,53
68	8	186	44186A00800186	Pancrudo	17.343,02		0,00	0,00	0,00	852,10	85,23	383,26	0,00	0,00
79	8	190	44186A00800190	Pancrudo	5.354,37		0,00	0,00	0,00	0,00	0,00	0,00	0,00	495,74
80	8	191	44186A00800191	Pancrudo	8.593,55		0,00	0,00	0,00	0,00	0,00	0,00	0,00	227,54
81	8	193	44186A00800193	Pancrudo	11.688,83		0,00	0,00	0,00	3.413,80	428,57	843,17	0,00	105,46
78	8	194	44186A00800194	Pancrudo	6.320,16		0,00	0,00	0,00	873,80	177,22	216,74	0,00	107,97
77	8	195	44186A00800195	Pancrudo	9.405,38		0,00	0,00	0,00	231,40	28,00	51,60	0,00	42,86
76	8	201	44186A00800201	Pancrudo	38.857,96	MO-02	2.160,55	0,00	563,81	39,60	5,70	14,23	0,00	3,62
70	8	202	44186A00800202	Pancrudo	7.763,13	MO-02	3.029,50	0,00	42,69	2.289,80	413,26	565,78	137,96	500,11
74	8	203	44186A00800203	Pancrudo	5.750,40	MO-02	5.643,80	440,91	3.682,63	165,50	16,64	39,40	944,21	565,24
83	8	204	44186A00800204	Pancrudo	7.773,29		0,00	0,00	0,00	915,80	91,60	230,30	0,00	0,00
84	8	206	44186A00800206	Pancrudo	7.299,93		0,00	0,00	0,00	585,70	58,60	148,42	0,00	0,00
86	8	211	44186A00800211	Pancrudo	39.434,57	MO-03	768,72	0,00	0,00	2.036,80	288,44	535,90	0,00	6,10
87	8	223	44186A00800223	Pancrudo	33.254,71	MO-03	14.588,68	402,51	3.750,20	2.207,80	585,92	523,07	3.927,05	2.562,64
88	8	226	44186A00800226	Pancrudo	5.171,36	MO-03	3.886,20	0,00	0,00	0,00	0,00	0,00	0,00	0,10
89	8	230	44186A00800230	Pancrudo	16.326,34	MO-03	1.875,75	0,00	0,00	0,00	0,00	0,00	0,00	0,00
73	8	232	44186A00800232	Pancrudo	25.097,38	MO-02	115,68	0,00	0,00	0,00	0,00	0,00	0,00	0,00
72	8	234	44186A00800234	Pancrudo	7.627,19	MO-02	2.300,25	0,00	10,82	0,00	0,00	0,00	0,00	0,00
90	8	237	44186A00800237	Pancrudo	14.678,45	MO-03	181,36	0,00	2.564,69	0,00	0,00	0,00	883,30	689,57
91	8	249	44186A00800249	Pancrudo	15.548,37	MO-03	1.397,15	0,00	350,16	0,00	0,00	0,00	0,00	0,00
67	8	350	44186A00800350	Pancrudo	2.288,16		0,00	0,00	0,00	197,80	19,73	90,86	0,00	0,00
99	9	148	44186A00900148	Pancrudo	11.962,61		0,00	0,00	0,00	0,00	0,00	0,00	0,00	59,48
98	9	149	44186A00900149	Pancrudo	10.612,49		0,00	0,00	0,00	0,00	0,00	0,00	0,00	181,64
96	9	158	44186A00900158	Pancrudo	11.179,46		0,00	0,00	0,00	0,00	0,00	0,00	0,00	21,97
94	9	159	44186A00900159	Pancrudo	12.764,68		0,00	0,00	0,00	0,00	0,00	0,00	0,00	148,45
95	9	161	44186A00900161	Pancrudo	2.854,34		0,00	0,00	0,00	0,00	0,00	0,00	0,00	324,59
92	9	165	44186A00900165	Pancrudo	42.302,05		0,00	0,00	0,00	0,00	0,00	0,00	0,00	846,49
7	9	168	44186A00900168	Pancrudo	153.622,49		0,00	0,00	0,00	0,00	0,00	0,00	0,00	304,18
93	9	325	44186A00900325	Pancrudo	7.436,65		0,00	0,00	0,00	0,00	0,00	0,00	0,00	13,14
46	304	25	44186A30400025	Pancrudo	2.921,80		0,00	0,00	0,00	394,30	39,43	153,17	0,00	0,00
45	304	49	44186A30400049	Pancrudo	1.532.130,74		0,00	0,00	0,00	13.282,10	1.327,25	6.386,13	0,00	0,00
47	304	51	44186A30400051	Pancrudo	234,38		0,00	0,00	0,00	107,90	11,72	83,34	0,00	0,00
53	305	29	44186A30500029	Pancrudo	56.000,65		0,00	0,00	0,00	177,50	17,76	168,34	0,00	0,00
55	305	54	44186A30500054	Pancrudo	15.776,68		0,00	0,00	0,00	1.225,30	122,50	612,16	0,00	0,00
54	305	67	44186A30500067	Pancrudo	726.315,11		0,00	0,00	0,00	10.684,10	1.068,23	5.239,37	0,00	0,00
51	305	70	44186A30500070	Pancrudo	2.392,04		0,00	0,00	0,00	59,80	6,01	30,61	0,00	0,00

1.17. Partes del proyecto que afectan a bienes, instalaciones, obras o servicios, centros o zonas dependientes de otras Administraciones Públicas, Organismos, Corporaciones, o Departamentos del Gobierno de Aragón, para que estos establezcan, si procede, el condicionado procedente en el trámite de informe.

Nº FINCA PROYECTO	DATOS DE LA FINCA					AFECCIÓN								
						AEROGENERADOR				LÍNEA SUBTERRÁNEA			CAMINOS	
	PGNO	PARC	REF CATASTRAL	TM	SUPERFICIE PARCELA (m2)	Aero	VUELO (m2)	ZAPATA (m2)	Plataforma (m2)	Long. (m)	Superficie Permanente (m2)	Superficie Temporal (m2)	Long. (m)	Superficie (m2)
3	8	46	44186A00800046	Pancrudo	35.412,66	MO-01	5.674,63	439,61	3.739,59	25,40	14,16	7,06	1.819,70	1.756,75
2	8	64	44186A00800064	Pancrudo	256.673,09	MO-01	15.789,05	0,00	2.140,57	9.338,90	2.069,78	3.418,29	2.802,98	7.583,19
12	8	77	44186A00800077	Pancrudo	102.412,02		0,00	0,00	0,00	9.936,50	991,81	4.560,90	0,00	0,00
24	8	102	44186A00800102	Pancrudo	18.328,91		0,00	0,00	0,00	674,60	67,47	337,23	0,00	0,00
82	8	196	44186A00800196	Pancrudo	18.695,09		0,00	0,00	0,00	1.793,00	179,28	444,87	0,00	0,00
75	8	207	44186A00800207	Pancrudo	33.997,14	MO-02	2.236,90	0,00	1.808,42	0,00	0,00	0,00	884,91	648,13
85	8	208	44186A00800208	Pancrudo	13.039,93		0,00	0,00	0,00	845,70	84,54	213,32	0,00	0,00
27	8	319	44186A00800319	Pancrudo	224.955,00		0,00	0,00	0,00	2.370,60	237,03	1.100,63	0,00	0,00
19	8	351	44186A00800351	Pancrudo	29.323,32		0,00	0,00	0,00	203,60	20,24	103,91	0,00	0,00
16	8	353	44186A00800353	Pancrudo	10.263,66		0,00	0,00	0,00	229,20	22,95	108,34	0,00	0,00
23	8	9002	44186A00809002	Pancrudo	2.828,56		0,00	0,00	0,00	427,50	42,92	296,33	0,00	0,00
17	8	9003	44186A00809003	Pancrudo	2.454,97		0,00	0,00	0,00	688,50	68,29	498,94	0,00	0,00
10	8	9004	44186A00809004	Pancrudo	15.107,45		0,00	0,00	0,00	0,00	2,10	157,38	5.934,45	5.140,90
66	8	9005	44186A00809005	Pancrudo	15.803,44	MO-02	774,62	0,00	0,00	142,10	14,27	123,18	4.367,82	2.204,22
29	303	9001	44186A30309001	Pancrudo	9.967,23		0,00	0,00	0,00	0,00	0,00	0,24	0,00	0,00
50	304	9002	44186A30409002	Pancrudo	20.412,79		0,00	0,00	0,00	69,30	6,96	34,47	0,00	0,00
48	304	9003	44186A30409003	Pancrudo	1.050,20		0,00	0,00	0,00	41,00	4,13	20,85	0,00	0,00
49	304	9004	44186A30409004	Pancrudo	6.165,74		0,00	0,00	0,00	0,00	0,00	266,05	0,00	0,00
56	305	9001	44186A30509001	Pancrudo	10.734,82		0,00	0,00	0,00	51,80	5,26	48,91	0,00	0,00
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57	306	95	44186A30600095	Pancrudo	12.473,46		0,00	0,00	0,00	266,80	26,71	131,28	0,00	0,00
58	306	110	44186A30600110	Pancrudo	1.855.696,51		0,00	0,00	0,00	15.765,90	1.576,65	7.885,55	0,00	0,00
59	306	9007	44186A30609007	Pancrudo	14.706,39		0,00	0,00	0,00	43,00	4,30	21,41	0,00	0,00

1.18. Documentación acreditativa de la capacidad legal, técnica y económica del solicitante.

SE HA INCLUIDO EN EL ANEXO III

1.19. Informe de las servidumbres aeronáuticas afectadas y, en caso de existir, estudio aeronáutico que asegure que las instalaciones no comprometen la seguridad de las operaciones de las aeronaves, de acuerdo con el Real Decreto 1541/2003, por el que se modifica el Decreto 584/1972, de servidumbres aeronáuticas, y el Decreto 1844/1975, de servidumbres aeronáuticas en helipuertos, para regular excepciones a los límites establecidos por las superficies limitadoras de obstáculos alrededor de aeropuertos y helipuertos.

Solicitud enviada a AESA.

MINISTERIO
DE TRANSPORTES, MOVILIDAD
Y AGENDA URBANA

AESA AGENCIA ESTATAL DE SEGURIDAD AÉREA

ENTRADA
Registro General AESA
Número: 2023063254
Fecha: 09/03/2023 16:15

JUSTIFICANTE DE PRESENTACIÓN DE REGISTRO

1. DATOS DE LOS SOLICITANTES

SISTEMAS ENERGÉTICOS SATURNO, SL (B04937934) representado por MICHAEL MATROSS NOBANDIANS (X9637577W)

2. ASUNTO

SOLICITUD DE EVALUACION DE SSAA
SOLICITUD DE EVALUACION DE ACTUACION EN CERCANIAS AFECTADAS POR ZONAS DE SERVIDUMBRES AERONAUTICAS CON ORIGEN O DESTINO EN ESPAÑA

PASEO DE LA CASTELLANA, 112
28046, MADRID
TEL: 91 396 80 00

MINISTERIO
DE TRANSPORTES, MOVILIDAD
Y AGENDA URBANA

AESA AGENCIA ESTATAL
DE SEGURIDAD AÉREA

PASEO DE LA CASTELLANA, 112
28046, MADRID
TEL: 91 396 80 00

MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA

SOLICITUD PARA LA TRAMITACIÓN DE SERVIDUMBRES AERONÁUTICAS

AESA AGENCIA ESTATAL DE SEGURIDAD AÉREA

DIRECCIÓN DE SEGURIDAD DE AEROPUERTOS Y NAVEGACIÓN AÉREA

SERVIDUMBRES AERONÁUTICAS

1. PETICIONARIO

1. CIF B04937934		2. Razón Social SISTEMAS ENERGÉTICOS SATURNO, SL				
3. Tipo Vía Calle	4. Domicilio Social Ramírez de Arellano 37	5. Número	6. Escalera	7. Piso	8. Puerta	9. Código Postal 28043
10. Municipio Madrid		11. Provincia Madrid				
12. Teléfono 664032997		13. Correo Electrónico alejandro.ribera@siemensgamesa.com				

2. REPRESENTANTE DEL PETICIONARIO

14. NIF X9637577W	15. Apellidos y Nombre MATROSS NOBANDIANS MICHAEL
16. Télefono	17. Correo Electrónico michael.matross@siemensgamesa.com

3. DATOS DE LA SOLICITUD

18. Tipo de la Solicitud Autorización	19. Código de la solicitud S23-3016

4. TIPOS DE ACTUACIÓN

20. Id	1				
21. Municipio	Pancrudo	22. Provincia	Teruel	23. Datum	WGS84
24. Huso	30	25. UTM X	667592,00	26.UTM Y	4514753,00
27. Altura solicitada (m.)	200,00	28. Cota terreno (m.s.n.m)	1381,00	29. Altura cubierta (m)	
30. Uso	Parque eólico	31. Carácter de uso	Permanente		
32. Descripción	MO01				
20. Id	2				
21. Municipio	Pancrudo	22. Provincia	Teruel	23. Datum	WGS84
24. Huso	30	25. UTM X	668447,00	26.UTM Y	4514590,00
27. Altura solicitada (m.)	200,00	28. Cota terreno (m.s.n.m)	1274,00	29. Altura cubierta (m)	
30. Uso	Parque eólico	31. Carácter de uso	Permanente		
32. Descripción	MO02				
20. Id	3				
21. Municipio	Pancrudo	22. Provincia	Teruel	23. Datum	WGS84
24. Huso	30	25. UTM X	668960,00	26.UTM Y	4514567,00
27. Altura solicitada (m.)	200,00	28. Cota terreno (m.s.n.m)	1267,00	29. Altura cubierta (m)	
30. Uso	Parque eólico	31. Carácter de uso	Permanente		
32. Descripción	MO03				

Ejemplar para el interesado

CORREO ELECTRÓNICO
servidumbres.aesa@seguridadaerea.es

www.seguridadaerea.gob.es

PASEO DE LA CASTELLANA, 112
28046 MADRID
TEL: +34 91 396 8320
FAX: +34 91 770 5459

5. MEDIOS AUXILIARES

33. Id	1Aux				
34. Municipio	Pancrudo	35. Provincia	Teruel	36. Datum	WGS84
37. Huso	30	38. UTM X	667592,00	39.UTM Y	4514753,00
40. Altura solicitada (m.)	140,00	41. Cota terreno (m.s.n.m)	1381,00	42. Tiempo estimado	1 mes
43. Tipo medio	Grúa móvil	44. Carácter de uso	40		
45. Descripción					

6. OBSERVACIONES

46. Observaciones

7. DOCUMENTACIÓN ADICIONAL

47. Descripción	48. Nombre del documento	49. Huella
Plano(s) de situación a escala	20230309161410-Plano situacion.pdf	9804e9bf6eee467ef2d2c163845dd8e0
Plano(s) acotado(s) de la planta y el alzado	20230309161417-Plano planta.pdf	2265e8e130d692ca5907d4dfa0a96f3e
En caso de representante, poder notarial o similar que lo acredite.	20230309161436-Poder notarial.pdf	1723787501acb5b69efdfe4954f1b66e

8. FECHA Y FIRMA

En Madrid
a 9 de marzo de 2023

Firma:

Firmado electrónicamente por

09/03/2023 16:14:41

Ejemplar para el interesado

MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA
AGENCIA ESTATAL DE SEGURIDAD AÉREA

La Agencia Estatal de Seguridad Aérea (En adelante AESA), como Responsable del Tratamiento de sus datos personales en cumplimiento *de la Ley Orgánica 3/2018, de 5 de diciembre, de Protección de Datos Personales y garantía de los derechos digitales y el Reglamento (UE) 2016/679 del Parlamento Europeo y del Consejo, de 27 de abril de 2016, relativo a la protección de las personas físicas en lo que respecta al tratamiento de datos personales y a la libre circulación de estos datos (Reglamento General de Protección de Datos)*, le informa, de manera explícita e inequívoca, que se va a proceder al tratamiento de sus datos de carácter personal obtenidos del "Formulario de solicitud para la tramitación de servidumbres aeronáuticas y obstáculos mayores de 100 m", para el tratamiento "***Autorización en materia de servidumbres aeronáuticas***" y con la finalidad:

- De "***Gestionar autorizaciones***". El usuario no podrá negar su consentimiento por ser este una obligación legal, definida por la "***Ley 48/1960, de 21 de julio, sobre Navegación Aérea.***"

Este tratamiento de datos de carácter personal se encuentra incluido en el Registro de Datos Personales de AESA.

La legalidad del tratamiento está basada en una obligación legal.

La información de carácter personal será conservada mientras sea necesaria o no se ejerza su derecho de cancelación o supresión.

La información puede ser cedida a terceros para colaborar en la gestión de los datos de carácter personal, únicamente para la finalidad descrita anteriormente.

La categoría de los datos de carácter personal que se tratan son únicamente ***"Datos identificativos (nombre, DNI, dirección, correo-e...)"***.

De acuerdo con lo previsto en la citada *Ley Orgánica de Protección de Datos y Garantías de Derechos Digitales* y el también citado *Reglamento General de Protección de Datos*, puede ejercitar sus derechos de Acceso, Rectificación, Supresión, Portabilidad de sus datos, la Limitación u Oposición a su tratamiento ante el Delegado de Protección de Datos, dirigiendo una comunicación al correo dpd.aesa@seguridadaerea.es

Para más información sobre el tratamiento de los datos de carácter personal pulse el siguiente enlace:

https://www.seguridadaerea.gob.es/es/quienes-somos/normativa-aesa/proteccion-de-datos

Ejemplar para el interesado

MINISTERIO
DE TRANSPORTES, MOVILIDAD
Y AGENDA URBANA

AGENCIA ESTATAL
DE SEGURIDAD AÉREA

1.20. Cuantos documentos adicionales relacionados con el expediente y relevantes para su resolución estime oportuno reclamar el órgano competente para la tramitación del expediente administrativo.

2. ANEXO II CARACTERISTICAS TÉCNICAS DE LOS AEROGENERADORES

2.1. Características y funcionamiento general de la plataforma de aerogeneradores SG 6.6 170

Developer Package

SG 6.6-170

Document ID and revision	Status	Date (yyyy-mm-dd)	Language
D2830475/006	Approved	2021-11-01	en-US

Original or translation of
Original

File name
D2830475_006-SGRE ON SG 6.6-170 Developer Package.docx/.pdf

Siemens Gamesa Renewable Energy S.A. Parque Tecnológico de Bizkaia, Edificio 222, 48170, Zamudio, Vizcaya, Spain
+34 944 03 73 52 – info@siemensgamesa.com – www.siemensgamesa.com

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Application of the Developer Package

The Developer Package serves the purpose of informing customers about the latest planned product development from Siemens Gamesa Renewable Energy A/S and its affiliates in the Siemens Gamesa group including Siemens Gamesa Renewable Energy S.A. and its subsidiaries (hereinafter "SGRE"). By sharing information about coming developments, SGRE can ensure that customers are provided with necessary information to make decisions.

Furthermore, the Developer Package can assist in guiding prospective customers with the indicated technical footprint of the SG 6.6-170 and the different product variants in cases where financial institutes, governing bodies, or permitting entities require product specific information in their decision processes.

All technical data contained in the Developer Package is subject to change owing to ongoing technical developments of the wind turbine. Consequently, SGRE and its affiliates reserve the right to change the below specifications without prior notice. Information contained within the Developer Package may not be treated separately or out of the context of the Developer Package.

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Table of contents

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1. Introduction

The SG 6.6-170 is a new variant of the next generation Siemens Gamesa Onshore Geared product platform called Siemens Gamesa 5.X, which builds directly on the SG 6.2-170 variant.

With an updated 83.3 m blade, an upgraded gearbox and an extensive tower portfolio including hub heights ranging from115 m to 155 m, the SG 6.6-170 aims at becoming a new benchmark in the market for efficiency and profitability.

This Developer Package describes the turbine technical specifications and provides information for the main components and subsystems.

For further information, please contact your regional SGRE Sales Manager.

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2. Technical Description

Rotor-Nacelle
The rotor is a three-bladed construction, mounted upwind of the tower. The power output is controlled by pitch and torque demand regulation. The rotor speed is variable and is designed to maximize the power output while maintaining loads and noise level.

The nacelle has been designed for safe access to all service points during scheduled service. In addition, the nacelle has been designed for safe presence of service technicians in the nacelle during Service Test Runs with the wind turbine in full operation. This allows a high-quality service of the wind turbine and provides optimum troubleshooting conditions.

Blades
Siemens Gamesa 5.X blades are made up of fiberglass infusion & carbon pultruded-molded components. The blade structure uses aerodynamic shells containing embedded spar-caps, bonded to two main epoxy-fiberglass-balsa/foam-core shear webs. The Siemens Gamesa 5.X blades use a blade design based on SGRE proprietary airfoils.

Rotor Hub
The rotor hub is cast in nodular cast iron and is fitted to the drive train low speed shaft with a flange connection. The hub is sufficiently large to provide room for service technicians during maintenance of blade roots and pitch bearings from inside the structure.

Drive train
The drive train is a 4-points suspension concept: main shaft with two main bearings and the gearbox with two torque arms assembled to the main frame.

The gearbox is in cantilever position; the gearbox planet carrier is assembled to the main shaft by means of a flange bolted joint and supports the gearbox.

Main Shaft
The low speed main shaft is forged and transfers the torque of the rotor to the gearbox and the bending moments to the bedframe via the main bearings and main bearing housings.

Main Bearings
The low speed shaft of the wind turbine is supported by two tapered roller bearings. The bearings are grease lubricated.

Gearbox
The gearbox is 3 stages high speed type (2 planetary + 1 parallel).

Generator
The generator is a doubly-fed asynchronous three phase generator with a wound rotor, connected to a frequency PWM converter. Generator stator and rotor are both made of stacked magnetic laminations and formed windings. Generator is cooled by air.

Mechanical Brake
The mechanical brake is fitted to the non-drive end of the gearbox.

Yaw System
A cast bed frame connects the drive train to the tower. The yaw bearing is an externally geared ring with a friction bearing. A series of electric planetary gear motors drives the yawing.

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Nacelle Cover
The weather screen and housing around the machinery in the nacelle is made of fiberglass-reinforced laminated panels.

Tower
The wind turbine is as standard mounted on a tapered tubular steel tower. Other tower technologies are available for higher hub heights. The tower has internal ascent and direct access to the yaw system and nacelle. It is equipped with platforms and internal electric lighting.

Controller
The wind turbine controller is a microprocessor-based industrial controller. The controller is complete with switchgear and protection devices and is self-diagnosing.

Converter
Connected directly with the Rotor, the Frequency Converter is a back to back 4Q conversion system with 2 VSC in a common DC-link. The Frequency Converter allows generator operation at variable speed and voltage, while supplying power at constant frequency and voltage to the MV transformer.

SCADA
The wind turbine provides connection to the SGRE SCADA system. This system offers remote control and a variety of status views and useful reports from a standard internet web browser. The status views present information including electrical and mechanical data, operation and fault status, meteorological data and grid station data.

Turbine Condition Monitoring
In addition to the SGRE SCADA system, the wind turbine can be equipped with the unique SGRE condition monitoring setup. This system monitors the vibration level of the main components and compares the actual vibration spectra with a set of established reference spectra. Review of results, detailed analysis and reprogramming can all be carried out using a standard web browser.

Operation Systems
The wind turbine operates automatically. It is self-starting when the aerodynamic torque reaches a certain value. Below rated wind speed, the wind turbine controller fixes the pitch and torque references for operating in the optimum aerodynamic point (maximum production) taking into account the generator capability. Once rated wind speed is surpassed, the pitch position demand is adjusted to keep a stable power production equal to the nominal value.

If high wind derated mode is enabled, the power production is limited once the wind speed exceeds a threshold value defined by design, until cut-out wind speed is reached and the wind turbine stops producing power.

If the average wind speed exceeds the maximum operational limit, the wind turbine is shut down by pitching of the blades. When the average wind speed drops back below the restart average wind speed, the systems reset automatically.

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3. Technical Specification

Rotor	
Type	3-bladed, horizontal axis
Position	Upwind
Diameter	170 m
Swept area	22,698 m²
Power regulation	Pitch & torque regulation with variable speed
Rotor tilt	6 degrees

Blade	
Type	Self-supporting
Blade length	83.5 m
Max chord	4.5 m
Aerodynamic profile	Siemens Gamesa proprietary airfoils
Material	G (Glassfiber) – CRP (Carbon Reinforced Plastic)
Surface gloss	Semi-gloss, < 30 / ISO2813
Surface color	Light grey, RAL 7035 or White, RAL 9018

Aerodynamic Brake	
Type	Full span pitching
Activation	Active, hydraulic

Load-Supporting Parts	
Hub	Nodular cast iron
Main shaft	Nodular cast iron
Nacelle bed frame	Nodular cast iron

Mechanical Brake	
Type	Hydraulic disc brake
Position	Gearbox rear end

Nacelle Cover	
Type	Totally enclosed
Surface gloss	Semi-gloss, <30 / ISO2813
Color	Light Grey, RAL 7035 or White, RAL 9018

Generator	
Type	Asynchronous, DFIG

Grid Terminals (LV)	
Baseline nominal power	6.6MW
Voltage	690 V
Frequency	50 Hz or 60 Hz

Yaw System	
Type	Active
Yaw bearing	Externally geared
Yaw drive	Electric gear motors
Yaw brake	Active friction brake

Controller	
Type	Siemens Integrated Control System (SICS)
SCADA system	SGRE SCADA System

Tower	
Type	Tubular steel / Hybrid
Hub height	115m to 165 m and site-specific
Corrosion protection	
Surface gloss	Painted
Color	Semi-gloss, <30 / ISO-2813 Light grey, RAL 7035 or White, RAL 9018

Operational Data	
Cut-in wind speed	3 m/s
Rated wind speed	11.5 m/s (steady wind without turbulence, as defined by IEC61400-1)
Cut-out wind speed	25 m/s
Restart wind speed	22 m/s

Weight	
Modular approach	Different modules depending on restriction

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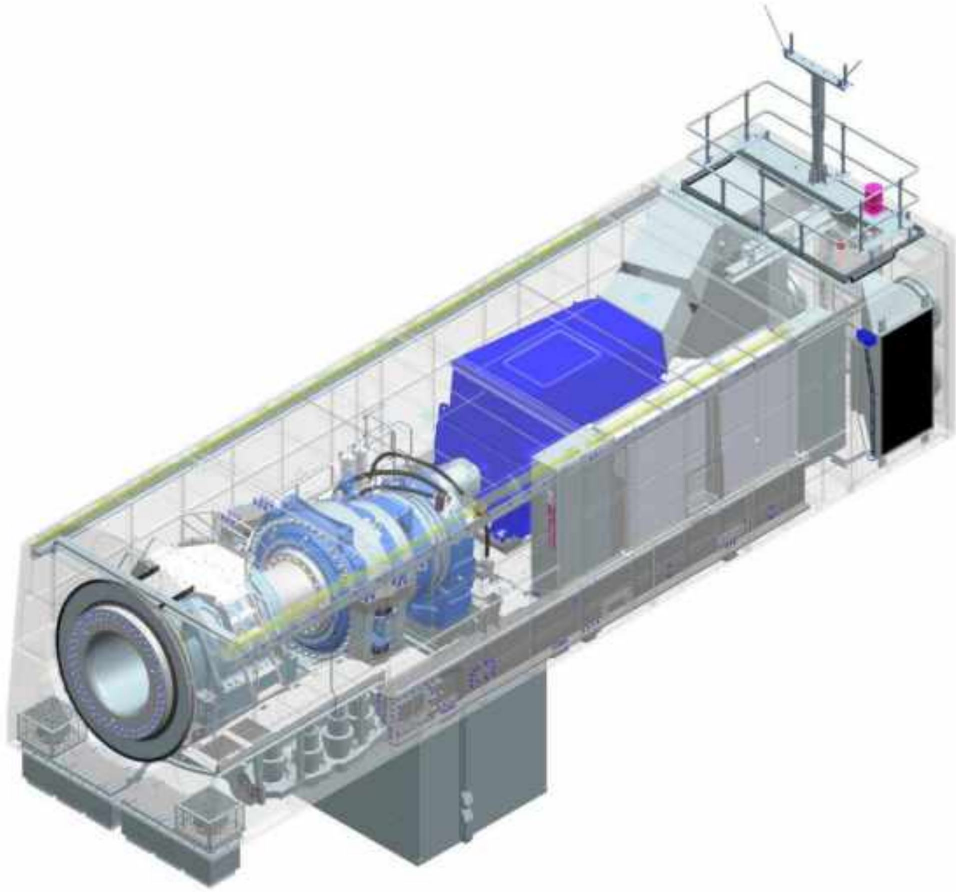
4. Nacelle Arrangement

The design and layout of the nacelle are preliminary and may be subject to changes during the development of the product.



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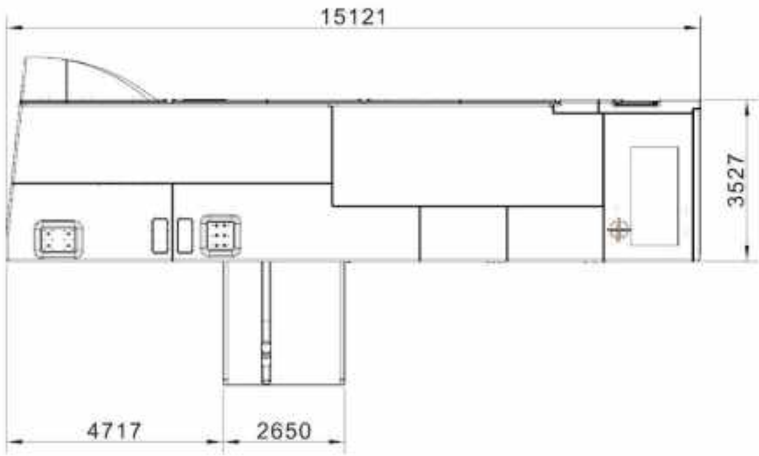
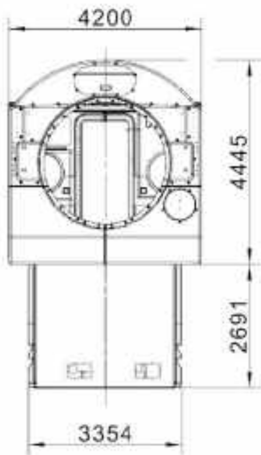
5. Nacelle Dimensions

The design and dimensions of the nacelle are preliminary and may be subject to changes during the development phases of the product.





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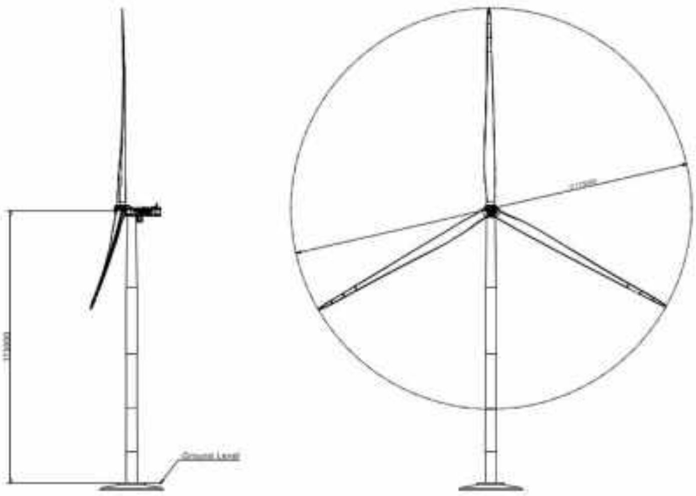
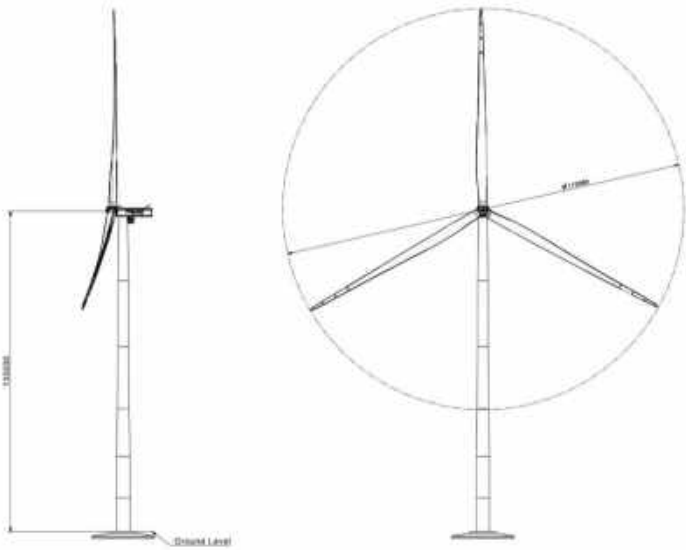
6. Elevation Drawing

6.1. SG 6.6-170 115 m



6.2. SG 6.6-170 135m



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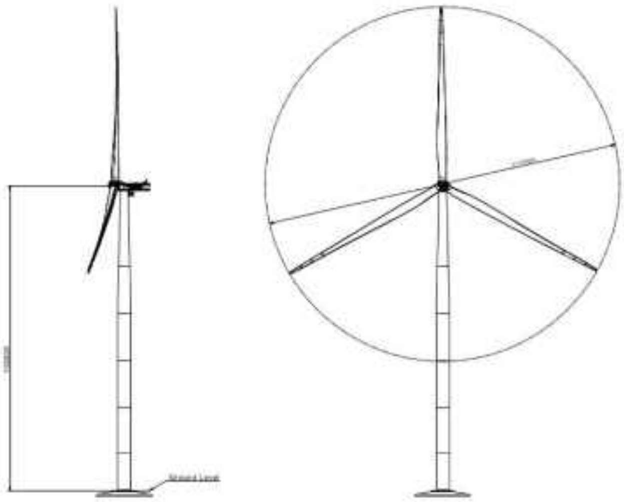
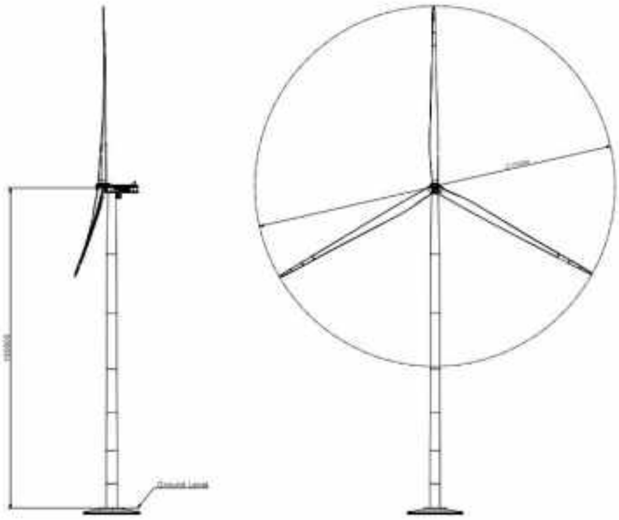
6.3. SG 6.6-170 145 m



6.4. SG 6.6-170 150 m



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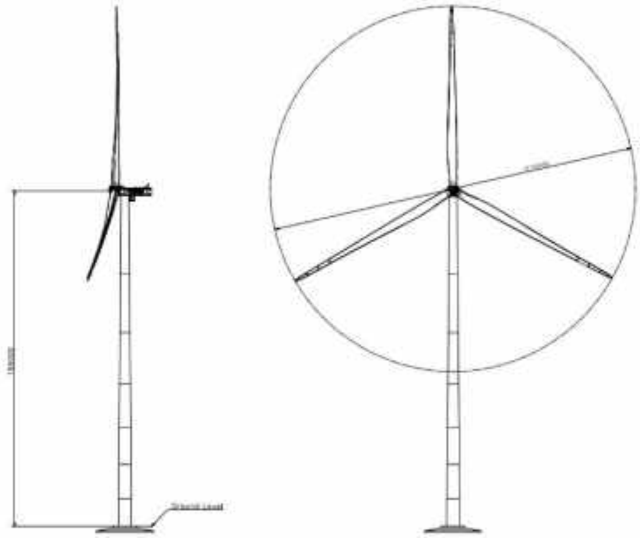
6.5. SG 6.6-170 155m



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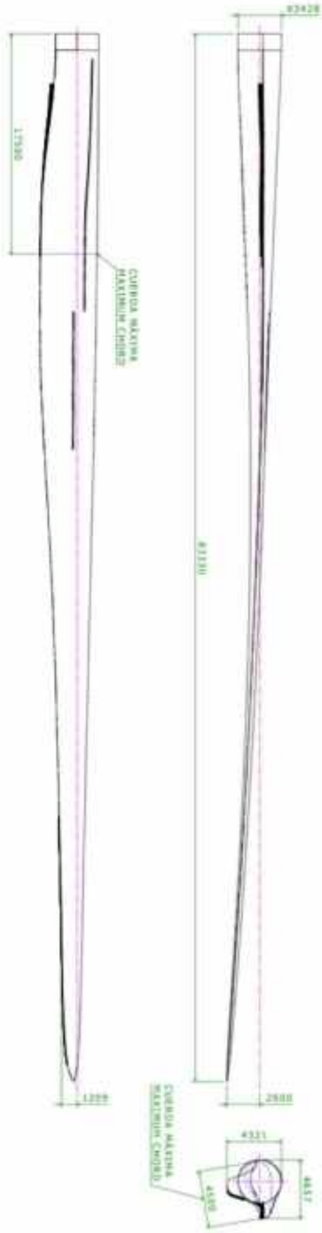
7. Blade Drawing



Dimensions in millimeter

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8. Tower Dimensions

SG 6.6-170 is offered with an extensive tower portfolio ranging from 115m-155m. All towers are designed in compliance with local logistics requirements. Information about other tower heights and logistic will be available upon request.

8.1. Tower hub height 115m. Tapered tubular steel tower

T115-56A	Section 1	Section 2	Section 3	Section 4	Section 5
External diameter upper flange (m)	4,700	4,485	4,490	4,490	3,503
External diameter lower flange (m)	4,700	4,700	4,485	4,490	4,490
Section's height (m)	13,274	18,200	22,960	28,000	29,970
Total weight (kg)	80089	78827	82122	74150	66283
Total Tower weight (kg)	381471				

8.2. Tower hub height 135m. Tapered tubular steel tower

T135-52A	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
External diameter upper flange (m)	5,683	5,680	4,832	4,524	4,518	3,503
External diameter lower flange (m)	6,000	5,683	5,680	4,832	4,524	4,518
Section's height (m)	14,160	17,360	20,160	26,040	27,720	26,974
Total weight (kg)	87.286	83.972	83.763	86.821	68.428	56.565
Total Tower weight (kg)	466.836					

8.3. Tower hub height 145m. Tapered tubular steel tower

T145-51A	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
External diameter upper flange (m)	6,390	6,390	6,390	6,200	4,895	3,503
External diameter lower flange (m)	6,400	6,390	6,390	6,390	6,200	4,895
Section's height (m)	17,924	21,280	22,400	22,400	22,400	36,000
Total weight (kg)	102614	102123	94231	82003	64794	84293
Total Tower weight (kg)	530058					

8.4. Tower hub height 150m. Tapered tubular steel tower

T150-50A	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
External diameter upper flange (m)	5,200	5,200	4,934	4,730	4,724	4,518	3,503
External diameter lower flange (m)	5,200	5,200	5,200	4,934	4,730	4,724	4,518
Section's height (m)	11,486	15,400	17,640	20,440	26,040	27,720	28,688
Total weight (kg)	89875	87575	86506	86758	87129	68463	60905
Total Tower weight (kg)	567212						

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8.5. Tower hub height 155m. Tapered tubular steel tower

T155-51A	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7
External diameter upper flange (m)	5,758	5,510	5,507	5,010	4,432	4,015	3,503
External diameter lower flange (m)	5,800	5,758	5,510	5,507	5,010	4,432	4,015
Section's height (m)	12,880	15,680	17,080	20,160	23,520	27,440	35,850
Total weight (kg)	90081	86929	85534	85621	85117	77921	74076
Total Tower weight (kg)	585279						

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9. Design Climatic Conditions

The design climatic conditions are the boundary conditions at which the turbine can be applied without supplementary design review. The specification in this document applies to SG 6.6-170.

Applications of the wind turbine in more severe conditions may be possible, depending upon the overall circumstances.

All references made to standards such as the IEC and ISO are further specified in the document "Codes and Standards". The design lifetime presented in the below table only applies to the fatigue load analysis performed in accordance with the presented IEC code. The term design lifetime and the use thereof do not constitute any express and/or implied warranty for actual lifetime and/or against failures on the wind turbines. Please see document for "design lifetime of wind turbine components" for more information.

Subject	ID	Issue	Unit	Value
0. Design lifetime	0.0	Design lifetime definition	-	IEC 61400-1[1]
	0.1	Design lifetime	years	25
1. Wind, operation	1.1	Wind definitions	-	IEC 61400-1
	1.2	IEC class	-	S
	1.3	Mean air density, ρ	kg/m³	1.25
	1.4	Mean wind speed, V_{ave}	m/s	7.38
	1.5	Weibull scale parameter, A	m/s	8.3
	1.6	Weibull shape parameter, k	-	2.64
	1.7	Wind shear exponent, α	-	0.36
	1.8	Reference turbulence intensity at 15 m/s, I_{ref}	-	0.16[2]
	1.9	Standard deviation of wind direction	Deg	-
	1.10	Maximum flow inclination	Deg	8
	1.11	Minimum turbine spacing, in rows	D	-
	1.12	Minimum turbine spacing, between rows	D	-
2. Wind, extreme	2.1	Wind definitions		IEC 61400-1
	2.2	Air density, ρ	kg/m³	1.225
	2.3	Reference wind speed average over 10 min at hub height, V_{ref}	m/s	42.5[3]
	2.4	Maximum 3 s gust in hub height, V_{e50}	m/s	59.5
	2.5	Maximum hub height power law index, α	-	0.11
	2.6	Storm turbulence	-	N/A
3. Temperature	3.1	Temperature definitions	-	IEC 61400-1
	3.2	Minimum temperature at 2 m, stand-still, $T_{min,s}$	Deg.C	-30
	3.3	Minimum temperature at 2 m, operation, $T_{min,o}$	Deg.C	-20
	3.4	Maximum temperature at 2 m, operation, $T_{max,o}$	Deg.C	40[4]
	3.5	Maximum temperature at 2 m, stand-still, $T_{max,s}$	Deg.C	50
4. Corrosion	4.1	Atmospheric-corrosivity category definitions	-	ISO 12944-2
	4.2	Internal nacelle environment (corrosivity category)	-	C3H (std) ≥C3H (high C)
	4.3	Exterior environment (corrosivity category)	-	C3H (std) ≥C3H (high C)

[1] All mentioning of IEC 61400-1 refers to to IEC 61400-1:2019 Ed4.
[2] NTM and ETM as per IEC A
[3] EWM as per IEC 2
[4] Maximum power output may be limited after an extended period of operation with a power output close to nominal power. The limitation depends on air temperature and air density as further described in the High Temperature Ride Through specification.

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Subject	ID	Issue	Unit	Value
5. Lightning	5.1	Lightning definitions	-	IEC61400-24:2010
	5.2	Lightning protection level (LPL)	-	LPL 1
6. Dust	6.1	Dust definitions	-	IEC 60721-3-4:1995
	6.2	Working environmental conditions	mg/m^3	Average Dust Concentration (95% time) → 0.05 mg/m^3
	6.3	Concentration of particles	mg/m^3	Peak Dust Concentration (95% time) → 0.5 mg/M^3
7. Hail	7.1	Maximum hail diameter	mm	20
	7.2	Maximum hail falling speed	m/s	20
8. Ice	8.1	Ice definitions	-	-
	8.2	Ice conditions	Days/yr	7
9. Solar radiation	9.1	Solar radiation definitions	-	IEC 61400-1
	9.2	Solar radiation intensity	W/m^2	1000
10. Humidity	10.1	Humidity definition	-	IEC 61400-1
	10.2	Relative humidity	%	Up to 95
11. Obstacles	11.1	If the height of obstacles within 500m of any turbine location height exceeds 1/3 of (H – D/2) where H is the hub height and D is the rotor diameter then restrictions may apply. Please contact Siemens Gamesa Renewable Energy for information on the maximum allowable obstacle height with respect to the site and the turbine type.		
12. Precipitation[5]	12.1	Annual precipitation	mm/yr	1100

[5] The specified maximum precipitation considers standard liquid Leading Edge Protection. For sites with higher annual precipitation and/or longer lifetime, it is recommended to consider optional reinforced Leading Edge Protection.

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10. Power Derating Curves by Ambient Temperature

10.1. SG 6.6-170 AM0 STD

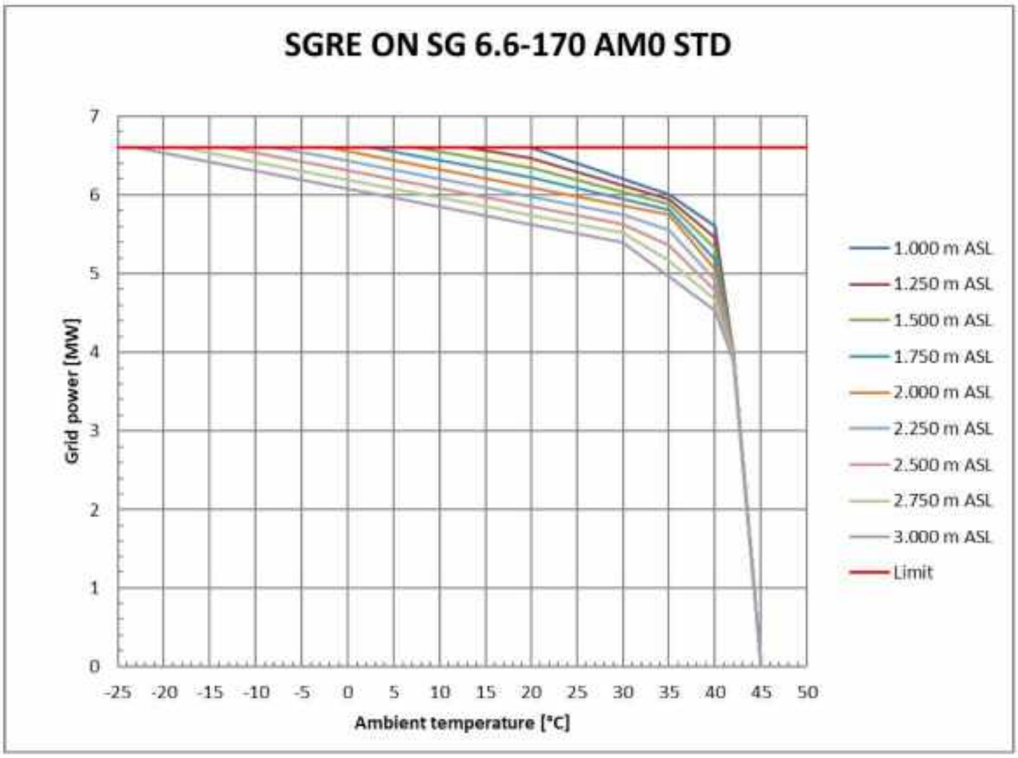

Figure 1: SG 6.6-170 AM0 STD power derating curves by ambient temperature and altitude

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Table 1: SG 6.6-170 AM0 STD grid power as function of ambient temperature and altitude

SGRE ON SG 6.6-170 AM0 STD					6.60	MW	8.83	RPM
Altitude							**1,000 m ASL**	
Temp.	**°C**	**20**	**35**	**40**	**42**	**45**		
Power	**MW**	**6.6**	**6**	**5.6**	**4**	**0**		
Load	**-**	**1**	**0.91**	**0.85**	**0.61**	**0**		
Altitude							1,250 m ASL	
Temp.	°C	13	20	35	40	42	45	
Power	MW	6.6	6.47	5.94	5.46	4	0	
Load	-	1	0.98	0.9	0.83	0.61	0	
Altitude							1,500 m ASL	
Temp.	°C	7.5	20	35	40	42	45	
Power	MW	6.6	6.35	5.88	5.32	4	0	
Load	-	1	0.96	0.89	0.81	0.61	0	
Altitude							1,750 m ASL	
Temp.	°C	2.5	20	35	40	42	45	
Power	MW	6.6	6.22	5.81	5.18	4	0	
Load	-	1	0.94	0.88	0.79	0.61	0	
Altitude							**2,000 m ASL**	
Temp.	**°C**	**-2**	**35**	**40**	**42**	**45**		
Power	**MW**	**6.6**	**5.75**	**5.05**	**4**	**0**		
Load	**-**	**1**	**0.87**	**0.77**	**0.61**	**0**		
Altitude							2,250 m ASL	
Temp.	°C	-8	-2	30	35	40	42	45
Power	MW	6.6	6.48	5.75	5.55	4.92	3.97	0
Load	-	1	0.98	0.87	0.84	0.74	0.6	0
Altitude							2,500 m ASL	
Temp.	°C	-13	-2	30	35	40	42	45
Power	MW	6.6	6.36	5.63	5.36	4.79	3.95	0
Load	-	1	0.96	0.85	0.81	0.73	0.6	0
Altitude							2,750 m ASL	
Temp.	°C	-18	-2	30	35	40	42	45
Power	MW	6.6	6.24	5.52	5.16	4.66	3.92	0
Load	-	1	0.95	0.84	0.78	0.71	0.59	0
Altitude							**3,000 m ASL**	
Temp.	**°C**	**-23**	**30**	**40**	**42**	**45**		
Power	**MW**	**6.6**	**5.4**	**4.53**	**3.9**	**0**		
Load	**-**	**1**	**0.82**	**0.69**	**0.59**	**0**		

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Table 2: SG 6.6-170 AM0 STD ambient temperature as function of grid power and altitude

SGRE ON SG 6.6-170 AM0 STD				6.6 MW		8.83 RPM			
Altitude m ASL	**1,000**	**1,250**	**1,500**	**1,750**	**2,000**	**2,250**	**2,500**	**2,750**	**3,000**
Power MW				Ambient temperature (°C)					
6.6	-20	-20	-20	-20	-20	-20	-20	-20	-23
6.6	20	13	7.5	2.5	-2	-8	-13	-18	-23
6.5	22.5	18.5	12.5	7	2.5	-3	-8.5	-13.5	-18.5
6.4	25	22	17.5	11.5	6.5	1.5	-3.5	-9	-14
6.3	27.5	25	21.5	16.5	11	6	1	-4.5	-10
6.2	30	27.5	24.5	21	15.5	10.5	5	0	-5.5
6.1	32.5	30.5	28	24.5	20	14.5	9.5	4.5	-1
6.0	35	33.5	31	28	24	19	14	8.5	3.5
5.9	36.5	35.5	34	32	28.5	23.5	18.5	13	8
5.8	37.5	36.5	35.5	35	33	27.5	22.5	17.5	12.5
5.7	39	37.5	36.5	36	35.5	31	27	22	17
5.6	40	38.5	37.5	36.5	36	34	30.5	26.5	21
5.5		39.5	38.5	37.5	37	35.5	32.5	30	25.5
5.4		40	39.5	38.5	37.5	36	34.5	31.5	30
5.3			40	39	38	37	35.5	33	31
5.2	40.5			40	39	38	36.5	34.5	32.5
5.1					39.5	38.5	37.5	35.5	33.5
5.0		40.5			40	39.5	38	36.5	34.5
4.9			40.5		40.5	40	39	37.5	35.5
4.8	41			40.5			40	38.5	37
4.7		41						39.5	38
4.6			41			40.5		40	39
4.5				41	41		40.5	40.5	40
4.4	41.5					41			40.5
4.3		41.5	41.5				41		
4.2				41.5	41.5	41.5		41	41
4.1							41.5	41.5	
4.0	42	42	42	42	42				41.5
3.9						42	42	42	42
3.3	42.5	42.5	42.5	42.5	42.5	42.5			
3.2							42.5	42.5	42.5
2.6	43	43	43	43	43	43	43	43	43
2.0	43.5	43.5	43.5	43.5	43.5				
1.9						43.5	43.5	43.5	43.5
1.3	44	44	44	44	44	44	44	44	44
0.6	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5
0.0	45	45	45	45	45	45	45	45	45

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10.2. SG 6.6-170 AM0 HT

Figure 2: SG 6.6-170 AM0 HT power derating curves by ambient temperature and altitude

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Table 3: SG 6.6-170 AM0 HT grid power as function of ambient temperature and altitude

SGRE ON SG 6.6-170 AM0 HT					6.60	MW	8.83	RPM			
Altitude							**1,000 m ASL**				
Temp.	**°C**	**25**	**40**	**44**	**46**						
Power	**MW**	**6.6**	**6**	**4.64**	**0**						
Load	**-**	**1**	**0.91**	**0.7**	**0**						
Altitude							1,250 m ASL				
Temp.	°C	13	25	40	43	44	46				
Power	MW	6.6	6.45	5.92	4.92	4.51	0				
Load	-	1	0.98	0.9	0.75	0.68	0				
Altitude							1,500 m ASL				
Temp.	°C	8	25	40	43	44	46				
Power	MW	6.6	6.29	5.84	4.87	4.06	0				
Load	-	1	0.95	0.89	0.74	0.61	0				
Altitude							1,750 m ASL				
Temp.	°C	3	25	40	43	44	46				
Power	MW	6.6	6.14	5.76	4.81	3.61	0				
Load	-	1	0.93	0.87	0.73	0.55	0				
Altitude							**2,000 m ASL**				
Temp.	**°C**	**-2**	**40**	**43**	**46**						
Power	**MW**	**6.6**	**5.65**	**4.75**	**0**						
Load	**-**	**1**	**0.86**	**0.72**	**0**						
Altitude							2,250 m ASL				
Temp.	°C	-7.5	-2	30	40	42	43	44	45	46	
Power	MW	6.6	6.48	5.76	5.53	4.99	4.66	3.12	1.19	0	
Load	-	1	0.98	0.87	0.84	0.76	0.71	0.47	0.18	0	
Altitude							2,500 m ASL				
Temp.	°C	-12.5	-2	30	40	42	43	44	45	46	
Power	MW	6.6	6.36	5.64	5.42	4.92	4.53	3.08	0.79	0	
Load	-	1	0.96	0.86	0.82	0.75	0.69	0.47	0.12	0	
Altitude							2,750 m ASL				
Temp.	°C	-17.5	-15	-2	30	40	42	43	44	45	46
Power	MW	6.6	6.54	6.25	5.53	5.3	4.86	4.21	3.04	0.39	0
Load	-	1	0.99	0.95	0.84	0.8	0.74	0.64	0.46	0.06	0
Altitude							**3,000 m ASL**				
Temp.	**°C**	**-23**	**-15**	**30**	**40**	**42**	**44**	**45**			
Power	**MW**	**6.6**	**6.42**	**5.41**	**5.18**	**4.79**	**2.99**	**0**			
Load	**-**	**1**	**0.97**	**0.82**	**0.78**	**0.73**	**0.45**	**0**			

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Table 4: SG 6.6-170 AM0 HT ambient temperature as function of grid power and altitude

SGRE ON SG 6.6-170 AM0 HT		6.6 MW		8.83 RPM					
Altitude	**m ASL**	**1,000**	**1,250**	**1,500**	**1,750**	**2,000**	**2,250**	**2,500**	**2,750**	**3,000**
Power	**MW**				**Ambient temperature (°C)**					
6.6		**-20**	-20	-20	-20	**-20**	-20	-20	-20	**-23**
6.6		**25**	13	8	3	**-2**	-7.5	-12.5	-17.5	**-23**
6.5		**27.5**	21	13.5	7.5	**2.5**	-3	-8	-13.5	**-18.5**
6.4		**30**	26.5	19	12.5	**7**	1.5	-3.5	-9	**-14**
6.3		**32.5**	29	24.5	17.5	**11.5**	6	1	-4.5	**-9.5**
6.2		**35**	32	28	22	**15.5**	10.5	5.5	0	**-5**
6.1		**37.5**	35	31.5	26.5	**20**	15	9.5	4.5	**-0.5**
6.0		**40**	38	35	30.5	**24.5**	19.5	14	9	**3.5**
5.9		**40.5**	40	38	34.5	**29**	24	18.5	13.5	**8**
5.8			40.5	40	38.5	**33.5**	28	23	18	**12.5**
5.7				40.5	40	**38**	32.5	27.5	22.5	**17**
5.6		**41**			40.5	**40**	37	32	26.5	**21.5**
5.5			41	41	41	**40.5**	40	36.5	31	**26**
5.4		**41.5**	41.5			**41**	40.5	40	35.5	**30.5**
5.3		**42**		41.5			41	40.5	40	**35**
5.2			42		41.5	**41.5**		41	40.5	**39**
5.1		**42.5**		42	42		41.5	41.5	41	**40.5**
5.0			42.5	42.5		**42**			41.5	**41**
4.9		**43**	43		42.5	**42.5**	42	42	42	**41.5**
4.8		**43.5**		43	43		42.5			**42**
4.7			43.5			**43**		42.5		
4.6		**44**					43			
4.5			44					43	42.5	
4.4				43.5						
4.3										**42.5**
4.2					43.5				43	
4.0				44						
3.9						**43.5**				
3.8							43.5	43.5		**43**
3.6					44				43.5	
3.4		**44.5**								**43.5**
3.3			44.5							
3.1						**44**	44			
3.0				44.5				44	44	
2.9										**44**
2.7					44.5					
2.3		**45**				**44.5**				
2.2			45							
2.1							44.5			
2.0				45						
1.9								44.5		

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SGRE ON SG 6.6-170 AM0 HT				6.6	MW	8.83	RPM			
Altitude	**m ASL**	**1,000**	**1,250**	**1,500**	**1,750**	**2,000**	**2,250**	**2,500**	**2,750**	**3,000**
Power	**MW**				**Ambient temperature (°C)**					
1.8					45					
1.7									44.5	
1.5						**45**				
1.4										**44.5**
1.1		**45.5**	45.5				45			
1.0				45.5						
0.9					45.5					
0.7						**45.5**		45		
0.5							45.5			
0.3								45.5	45	
0.1									45.5	
0.0		**46**	46	46	46	**46**	46	46	46	**45**

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11. Flexible Rating Specification

The SG 6.6-170 is offered with various operational modes that are achieved through the flexible operating capacity of the product, enabling the configuration of an optimal power rating that is best suited for each wind farm. The operating modes are broadly divided into two categories: Application Modes and Noise Reduction System Modes[6].

11.1. Application Modes

Application Modes ensure optimal turbine performance with maximum power rating allowed by the structural and electrical systems of the turbine. There are multiple Application Modes, offering flexibility of different power ratings. All Application Modes are part of the turbine Certificate.
SG 6.6-170 can offer increased operation flexibility with modes based on AM 0 with reduced power rating. These modes are created with same noise performance of the corresponding Application Mode 0 but with decreased rating and improved temperature de-rating than the corresponding Application Mode 0. In addition, the turbine's electrical performance is constant for the full set of application modes, as shown on the table below.
The SG 6.6-170 is designed with a base wind class, applicable to AM 0, of IEC S for 25 year lifetime. All other Application Modes may be analyzed for more demanding site conditions.

11.2. Full list of Application Modes

Rotor Configuration	Application mode	Rating [MW]	Noise [dB(A)]	Power Curve Document	Acoustic Emission Document	Electrical Performance			Max temperature With Max active power and electrical capabilities[7]
						Cos Phi	Voltage Range	Frequency range	
SG 6.6-170	AM 0	6.6	106.0	D2849164	D2844535	0.9	[0.95,1.12] Un	±3% Fn	20ºC
SG 6.6-170	AM-1	6.5	106.0	D2861213	D2844535	0.9	[0.95,1.12] Un	±3% Fn	23ºC
SG 6.6-170	AM-2	6.4	106.0	D2863704	D2844535	0.9	[0.95,1.12] Un	±3% Fn	25ºC
SG 6.6-170	AM-3	6.3	106.0	D2863706	D2844535	0.9	[0.95,1.12] Un	±3% Fn	28ºC
SG 6.6-170	AM-4	6.2	106.0	D2863708	D2844535	0.9	[0.95,1.12] Un	±3% Fn	30ºC
SG 6.6-170	AM-5	6.1	106.0	D2863710	D2844535	0.9	[0.95,1.12] Un	±3% Fn	33ºC
SG 6.6-170	AM-6	6.0	106.0	D2863712	D2844535	0.9	[0.95,1.12] Un	±3% Fn	35ºC

[6] It should be noted that the definition of various modes as described in this chapter is applicable in combination with standard temperature limits and grid capabilities of the turbine.

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11.3. Noise Reduction System (NRS) Modes ®

The Noise Reduction System is an optional module available with the basic SCADA configuration and it therefore requires the presence of a SGRE SCADA system to work. NRS ® Modes are noise curtailed modes enabled by the Noise Reduction System ®. The purpose of this system is to limit the noise emitted by any of the functioning turbines and thereby comply with local regulations regarding noise emissions.

Noise control is achieved through the reduction of active power and rotational speed of the wind turbine. This reduction is dependent on the wind speed. The Noise Reduction System ® controls the noise settings of each turbine to the most appropriate level at all times, in order to keep the noise emissions within the limits allowed. Sound Power Levels correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

The activation of NRS ® modes depend on the tower type selection. This information can be provided upon request.

Rotor Configuration	NRS Mode	Rating [MW]	Noise [dB(A)]	Power Curve Document	Acoustic Emission Document	Max temperature With Max active power and electrical capabilities[8]
SG 6.6-170	N1	6.40	105.5	D2863684	D2844535	20ºC
SG 6.6-170	N2	6.10	104.5	D2863686	D2844535	20ºC
SG 6.6-170	N3	5.24	103.0	D2863688	D2844535	30ºC
SG 6.6-170	N4	5.12	102.0	D2863690	D2844535	30ºC
SG 6.6-170	N5	4.87	101.0	D2863692	D2844535	30ºC
SG 6.6-170	N6	4.52	100.0	D2863697	D2844535	30ºC
SG 6.6-170	N7	3.60	99.0	D2863699	D2844535	30ºC

11.4. Control Strategy

The Application Modes are implemented and controlled in the Wind Turbine Controller. The NRS ® modes are also handled in the SCADA, however it shall also be possible to deploy custom NRS ® modes from the SCADA to the Wind Turbine Controller.

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12. Standard Ct and Power Curve, Rev. 0, Mode AM 0

12.1. Standard Power Curve, Application Mode - AM 0

Air density= 1.225 kg/m^3

Validity range:

Wind Shear (10min average)	≤ 0.3
Turbulence intensity TI [%] for bin i	$5\%\frac{(0.75v_i+5.6)}{v_i} < TI_i < 12\%\frac{(0.75v_i+5.6)}{v_i}$
Terrain	Not complex according to IEC 61400-12-1
Upflow β [°]	-2° ≤ β ≤ +2°
Grid frequency [Hz]	± 0.5 Hz

Other considerations: Clean rotor blades, substantially horizontal, undisturbed air flow, turbine operated within nominal limits according to the Electrical Specification.

Next table shows the electrical power as a function of wind speed in hub height, averaged in ten minutes, for air density = 1.225 kg/m^3. The power curve does not include losses in the transformer and high voltage cables.

For a detailed description of Application Mode – AM 0, please refer to latest version of Flexible Rating Specification (D2834432).

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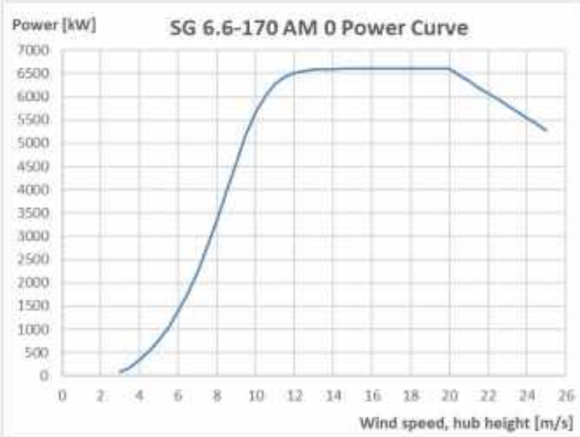
SG 6.6-170 Rev. 0, AM 0	
Wind Speed [m/s]	Power [kW]
3.0	89
3.5	178
4.0	328
4.5	522
5.0	758
5.5	1040
6.0	1376
6.5	1771
7.0	2230
7.5	2757
8.0	3346
8.5	3974
9.0	4600
9.5	5176
10.0	5660
10.5	6024
11.0	6271
11.5	6424
12.0	6510
12.5	6556
13.0	6579
13.5	6590
14.0	6596
14.5	6598
15.0	6599
15.5	6600
16.0	6600
16.5	6600
17.0	6600
17.5	6600
18.0	6600
18.5	6600
19.0	6600
19.5	6600
20.0	6600
20.5	6468
21.0	6336
21.5	6204
22.0	6072
22.5	5940
23.0	5808
23.5	5676
24.0	5544
24.5	5412
25.0	5280



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The annual energy production data for different annual mean wind speeds in hub height are calculated from the above power curve assuming a Weibull wind speed distribution, 100 percent availability, and no reductions due to array losses, grid losses, or other external factors affecting the production.

AEP [MWh]		Annual Average Wind Speed [m/s] at Hub Height										
		5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
Weibull K	1.5	12851	15328	17704	19934	21989	23852	25514	26972	28233	29302	30193
	2.0	11605	14534	17472	20334	23061	25614	27970	30114	32035	33730	35195
	2.5	10392	13504	16768	20051	23247	26281	29107	31704	34061	36180	38062

Annual Production [MWh] SG 6.6-170 Rev 0, AM 0 wind turbine for the standard version, as a function of the annual mean wind speed at hub height, and for different Weibull parameters. Air density 1.225 kg/m^3

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12.2. Standard Ct Curve, Application Mode - AM 0

Air density= 1.225 kg/m^3

Validity range:

Wind Shear (10min average)	≤ 0.3
Turbulence intensity TI [%] for bin i	$5\% \frac{(0.75v_i + 5.6)}{v_i} < TI_i < 12\% \frac{(0.75v_i + 5.6)}{v_i}$
Terrain	Not complex according to IEC 61400-12-1
Upflow β [°]	-2° ≤ β ≤ +2°
Grid frequency [Hz]	± 0.5 Hz

Other considerations: Clean rotor blades, substantially horizontal, undisturbed air flow, turbine operated within nominal limits according to the Electrical Specification.

The thrust coefficient Ct is used for the calculation of the wind speed deficit in the wake of a wind turbine.

Ct is defined by the following expression:

$Ct = F / (0.5 * ad * w^2 * A)$

where

F = Rotor force [N]

ad = Air density [kg/m^3]

w = Wind speed [m/s]

A = Swept area of rotor [m^2]

For a detailed description of Application Mode - AM 0, please refer to latest version of Flexible Rating Specification (D2834432).

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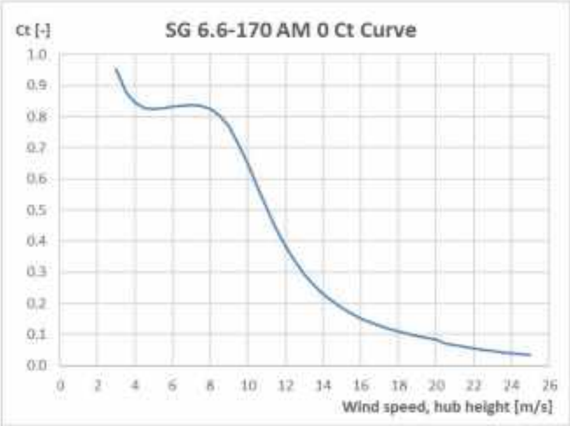
SG 6.6-170 Rev. 0, AM 0	
Wind Speed [m/s]	Ct [-]
3.0	0.953
3.5	0.880
4.0	0.847
4.5	0.828
5.0	0.824
5.5	0.828
6.0	0.833
6.5	0.836
7.0	0.837
7.5	0.835
8.0	0.825
8.5	0.804
9.0	0.766
9.5	0.713
10.0	0.648
10.5	0.576
11.0	0.506
11.5	0.440
12.0	0.383
12.5	0.335
13.0	0.294
13.5	0.260
14.0	0.231
14.5	0.206
15.0	0.186
15.5	0.168
16.0	0.152
16.5	0.139
17.0	0.128
17.5	0.118
18.0	0.109
18.5	0.102
19.0	0.095
19.5	0.090
20.0	0.084
20.5	0.071
21.0	0.065
21.5	0.060
22.0	0.055
22.5	0.051
23.0	0.047
23.5	0.043
24.0	0.040
24.5	0.037
25.0	0.034



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13. Acoustic Emission

Typical Sound Power Levels
The sound power levels are presented with reference to the code IEC 61400-11 ed. 3.0 (2012). The sound power levels (L_{WA}) presented are valid for the corresponding wind speeds referenced to the hub height.

Wind speed [m/s]	3	4	5	6	7	8	9	10	11	12	Up to cut-out
AM 0	92.0	92.0	94.5	98.4	101.8	104.7	106.0	106.0	106.0	106.0	106.0
AM-1	92.0	92.0	94.5	98.4	101.8	104.7	106.0	106.0	106.0	106.0	106.0
AM-2	92.0	92.0	94.5	98.4	101.8	104.7	106.0	106.0	106.0	106.0	106.0
AM-3	92.0	92.0	94.5	98.4	101.8	104.7	106.0	106.0	106.0	106.0	106.0
AM-4	92.0	92.0	94.5	98.4	101.8	104.7	106.0	106.0	106.0	106.0	106.0
AM-5	92.0	92.0	94.5	98.4	101.8	104.7	106.0	106.0	106.0	106.0	106.0
AM-6	92.0	92.0	94.5	98.4	101.8	104.7	106.0	106.0	106.0	106.0	106.0
N1	92.0	92.0	94.5	98.4	101.8	104.7	105.5	105.5	105.5	105.5	105.5
N2	92.0	92.0	94.5	98.4	101.8	104.5	104.5	104.5	104.5	104.5	104.5
N3	92.0	92.0	94.5	98.4	101.8	103.0	103.0	103.0	103.0	103.0	103.0
N4	92.0	92.0	94.5	98.4	101.8	102.0	102.0	102.0	102.0	102.0	102.0
N5	92.0	92.0	94.5	98.4	101.0	101.0	101.0	101.0	101.0	101.0	101.0
N6	92.0	92.0	94.5	98.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
N7	92.0	92.0	94.5	98.4	99.0	99.0	99.0	99.0	99.0	99.0	99.0

Table 1: Acoustic emission, L_{WA} [dB(A) re 1 pW] (10 Hz to 10 kHz)

Low Noise Operations (NRS ®)
The lower sound power level is also available and can be achieved by adjusting the turbines controller settings, i.e. an optimization of rpm and pitch. The noise settings are not static and can be applied to optimize the operational output of the turbine. Noise settings can be tailored to time of day as well as wind direction to offer the most suitable solution for a specific location. This functionality is controlled via the WebWPS SCADA system and is described further in the white paper on Noise Reduction Operations. Furthermore, tailored power curves can be provided which take wind speed into consideration allowing for management of the turbine output power and noise emission level to comply with site specific noise requirements. Tailored power curves are project and turbine specific and will therefore require Siemens Gamesa Siting involvement to provide the optimal solutions. The lower sound power levels may not be applicable to all tower variants. Please contact Siemens Gamesa for further information.

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1/1 oct.band, center freq.	63	125	250	500	1000	2000	4000	8000
AM 0	86.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
AM-1	86.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
AM-2	86.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
AM-3	86.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
AM-4	86.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
AM-5	86.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
AM-6	86.5	93.4	96.1	97.9	101.8	99.9	93.3	83.0
N1	86.2	93.0	95.6	97.4	101.3	99.4	92.8	82.5
N2	85.7	92.0	94.6	96.4	100.3	98.4	91.8	81.5
N3	84.9	90.7	93.0	94.8	98.7	96.8	90.2	79.9
N4	84.4	89.7	92.0	93.8	97.7	95.8	89.2	78.9
N5	83.8	88.7	91.0	92.8	96.7	94.8	88.2	77.9
N6	83.3	87.8	90.0	91.8	95.7	93.8	87.2	76.9
N7	82.7	86.8	89.0	90.8	94.7	92.8	86.2	75.9

Table 2: Typical 1/1 octave band spectrum for 63 Hz to 8 kHz at rated power level at 12 m/s

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14. Electrical Specifications

Nominal output and grid conditions

Nominal power	6600 kW
Nominal voltage	690 V
Power factor correction	Frequency converter control
Power factor range	0.9 capacitive to 0.9 inductive at nominal balanced voltage

Generator

Type	DFIG Asynchronous
Maximum power	6750 kW @20°C ext. ambient
Nominal speed	1120 rpm-6p (50Hz) 1344 rpm-6p (60Hz)

Generator Protection

Insulation class	Stator H/H Rotor H/H
Winding temperatures	6 Pt 100 sensors
Bearing temperatures	3 Pt 100
Slip Rings	1 Pt 100
Grounding brush	On side no coupling

Generator Cooling

Cooling system	Air cooling
Internal ventilation	Air
Control parameter	Winding, Air, Bearings temperatures

Frequency Converter

Operation	4Q B2B Partial Load
Switching	PWM
Switching freq., grid side	2.5 kHz
Cooling	Liquid/Air

Main Circuit Protection

Short circuit protection	Circuit breaker
Surge arrester	varistors

Peak Power Levels

10 min average	Limited to nominal

Grid Capabilities Specification

Nominal grid frequency	50 or 60 Hz
Minimum voltage	85 % of nominal
Maximum voltage	113 % of nominal
Minimum frequency	92 % of nominal
Maximum frequency	108 % of nominal
Maximum voltage imbalance (negative sequence of component voltage)	≤5 %
Max short circuit level at controller's grid Terminals (690 V)	82 kA

Power Consumption from Grid (approximately)

At stand-by,No yawing	10 kW
At stand-by, yawing	50 kW

Controller back-up

UPS Controller system	Online UPS, Li battery
Back-up time	1 min
Back-up time Scada	Depend on configuration

Transformer Specification

Transformer impedance requirement	8.5 % - 10.5%
Secondary voltage	690 V
Vector group	Dyn 11 or Dyn 1 (star point earthed)

Earthing Specification

Earthing system	Acc. to IEC62305-3 ED 1.0:2010
Foundation reinforcement	Must be connected to earth electrodes
Foundation terminals	Acc. to SGRE Standard
HV connection	HV cable shield shall be connected to earthing system

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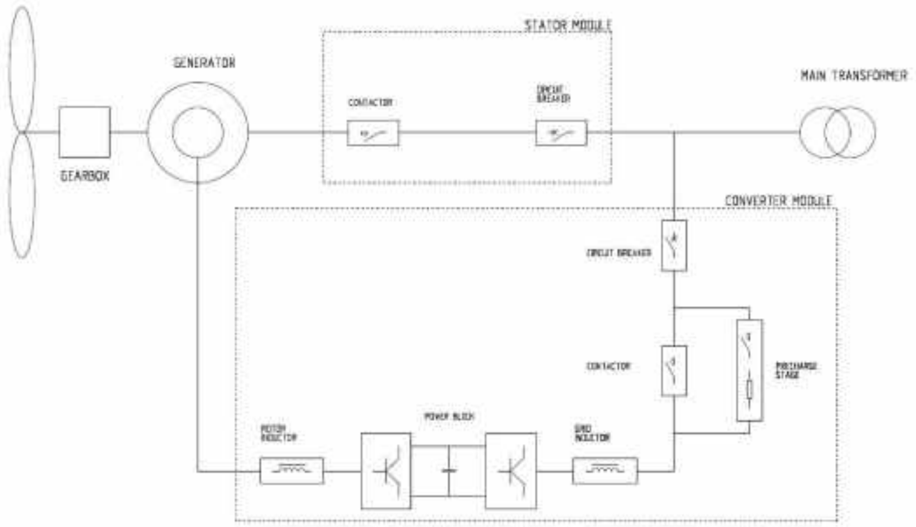
15. Simplified Single Line Diagram



16. Transformer Specifications ECO 30 kV

Transformer

Type	Liquid filled
Max Current	7.11 kA + harmonics at nominal voltage ± 10 %
Nominal voltage	30/0.69 kV
Frequency	50 Hz
Impedance voltage	9.5% ± 8.3% at ref. 6.5 MVA
Tap Changer	±2x2.5% (optional)
Loss (P_0 /$P_{k75°C}$)	4.77/84.24 kW
Vector group	Dyn11
Standard	IEC 60076 ECO Design Directive

Transformer Cooling

Cooling type	KFWF
Liquid inside transformer	K-class liquid
Cooling liquid at heat exchanger	Glysantin

Transformer Monitoring

Top oil temperature	PT100 sensor
Oil level monitoring sensor	Digital input
Overpressure relay	Digital input

Transformer Earthing

Star point	The star point of the transformer is connected to earth

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17. Switchgear Specifications

The switchgear will be chosen as factory-assembled, type-tested, and maintenance-free high-voltage switchgear with single-busbar system. The device will be metal-enclosed, metal-clad, gas-isolated, and conforms to the stipulations of IEC 62271-200.

The switchgear vessel of the gas-insulated switchgear is classified according to IEC as a "sealed pressure system". It is gas-tight for life. The switchgear vessel accommodates the busbar system and switching device (such as vacuum circuit breaker, three-position switch disconnecting and earthing).

The vessel is filled with sulphur hexafluoride (SF6) at the factory. This gas is non-toxic, chemically inert, and features a high dielectric strength. Gas work on site is not required, and even in operation it is not necessary to check the gas condition or refill, the vessel is designed for being gas tight for life.To monitor the gas density, every switchgear vessel is equipped with a ready-for-service indicator at the operating front. This is a mechanical red/green indicator, self-monitoring and independent of temperature and variations of the ambient air pressure.

MV cables connected to the grid cable- and circuit-breaker feeders are connected via cast-resin bushings leading into the switchgear vessel. The bushings are designed as outside-cone system type "C" M16 bolted 630 A connections according to EN 50181. The compartment is accessible from the front. A mechanical interlock ensures that the cable compartment cover can only be removed when the three-position switch is in the earthed position.

The circuit-breaker operates based on vacuum switching technology. The vacuum interrupter unit is installed in the switchgear vessel together with the three-position switch and is thus protected from environmental influences. The operating mechanism of the circuit-breaker is located outside the vessel. Both, the interrupters and the operating mechanisms, are maintenance-free.

Padlock facilities are provided to lock the switchgear from operation in disconnector open and close position, earth switch open and close position, and circuit breaker open position, to prevent improper operation of the equipment.

Capacitive Voltage detection systems are installed both in the grid cable and the circuit breaker feeders. Pluggable indicators can be plugged at the switchgear front to show the voltage status.

The switchgear is equipped with an over-current protection relay with the functions over current, short circuit and earth fault protection. The relay ensures that the transformer is disconnected if a fault occurs in the transformer or the high voltage installation in the wind turbine. The relay is adjustable to obtain selectivity between low voltage main breaker and the circuit breaker in the substation.

The protective system shall cause the circuit breaker opening with a dual powered relay (self-power supply + external auxiliary power supply possibility). It imports its power supply from current transformers, that are already mounted on the bushings inside the circuit breaker panel and is therefore ideal for wind turbine applications.

Trip signals from the transformer auxiliary protection and wind turbine controller can also disconnect the switchgear.

The switchgear consists of two or more feeders*; one circuit breaker feeder for the wind turbine transformer also with earthing switch and one or more grid cable feeders** with load break switch and earthing switch.

The switchgear can be operated local at the front or by use of portable remote control (circuit breaker only) connected to a control box at the wind turbine entrance level.

* Up to four feeders
** SGRE to be contacted for possible feeder configurations of circuit breaker and grid feeder combinations.

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The switchgear is located in the bottom of the tower. The main transformer, LV switchgear and converters are located on the nacelle level above the tower.

Grid cables, from substation and/or between the turbines, must be installed at the bushings in the grid cable feeder cubicles of the switchgear. These bushings are the interface/grid connection point of the turbine. It is possible to connect grid cables in parallel by installing the cables on top of each other. The space in the MV cable compartments of the switchgear allows the installation of two connectors per phase or one connector + surge arrester per phase.

The transformer cables are installed at the bottom of the circuit breaker feeder. The cable compartment is accessible from the front. A mechanical interlock ensures that the cable compartment cover can only be removed when the three-position switch is in the earthed position.

Optionally, the switchgear can be delivered with surge arresters installed in between the switchgear and wind turbine transformer on the outgoing bushings of the circuit breaker feeder.

17.1. Technical Data for Switchgear

Switchgear			
Make	Ormazabal or Siemens	**Circuit breaker feeder**	
Type	8DJH, 8DJH 36/cgmcosmos cgm.3	Rated current, Cubicle	630 A
Rated voltage	20-40,5(Um) kV	Rated current circuit breaker	630 A
Operating voltage	20-40,5(Um) kV	Short time withstand current	20 kA/1s
Rated current	630 A	Short circuit making current	50 kA/1s
Short time withstand current	20 kA/1s	Short circuit breaking current	20 kA/1s
Peak withstand current	50 kA	Three position switch	Closed, open, earthed
Power frequency withstand voltage	70 kV	Switch mechanism	Spring operated
		Tripping mechanism	Stored energy
Lightning withstand voltage	170 kV		
Insulating medium	SF_6	Control	Local
Switching medium	Vacuum	Coil for external trip	230V AC
Consist of	2/3/4 panels	Voltage detection system	Capacitive
Grid cable feeder	Cable riser or line cubicle		
Circuit breaker feeder	Circuit breaker	**Protection**	
Degree of protection, vessel	IP65	Over-current relay	Self-powered
		Functions	50/51 50N/51N
		Power supply	Integrated CT supply
Internal arc classification IAC:	A FL 20 kA 1s		
Pressure relief	Downwards		
Standard	IEC 62271	**Interface- MV Cables**	630 A bushings type C
Temperature range	-25°C to +45°C	Grid cable feeder	M16
			Max 2 feeder cables
Grid cable feeder (line cubicle)		Cable entry	From bottom
		Cable clamp size (cable outer diameter) **	26 - 38mm
Rated current, Cubicle	630 A		36 - 52mm
Rated current, load breaker	630 A		50 - 75mm
Short time withstand current	20 kA/1s	Circuit breaker feeder	630 A bushings type C
Short circuit making current	50 kA/1s	Cable entry	M16
Three position switch	Closed, open, earthed		From bottom
Switch mechanism	Spring operated	**Interface to turbine control**	
Control	Local	Breaker status	
Voltage detection system	Capacitive	SF6 supervision	1 NO contact
		External trip	1 NO contact

*Cable clamps are not part of switchgear delivery.

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18. Grid Performance Specifications – 50 Hz

This document describes the grid performance of the Siemens Gamesa 5.X, 50 Hz wind turbine. Siemens Gamesa Renewable Energy (SGRE) will provide wind turbine technical data for the developer to use in the design of the wind power plant and the evaluation of requirements compliance. The developer will be responsible for the evaluation and ensuring that the requirements are met for the wind power plant.

The capabilities described in this document assume that the electrical network is designed to be compatible with operation of the wind turbine. SGRE will provide a document with guidance to perform an assessment of the network's compatibility.

18.1. Fault Ride Through (FRT) Capability

The wind turbine is capable of operating when voltage transient events occur on the interconnecting transmission system above and below the standard voltage lower limits and time slot according to Figure 1 and Figure 2.

This performance assumes that the installed amount of wind turbines is in the right proportion to the strength of the grid, which means that the short circuit ratio (Sk/Sn) and the X/R ratio of the grid at the wind turbine transformer terminals must be adequate.

Evaluation of the wind turbine's fault ride through capability in a specific system must be based on simulation studies using the specific network model and a dynamic wind turbine model provided by SGRE. This model is a reduced order model, suitable for balanced simulations with time steps between 4-10 ms.

The standard voltage limits for the Siemens Gamesa 5.X, 50 Hz wind turbine are presented in Figure 1 between 0 - 70 seconds.

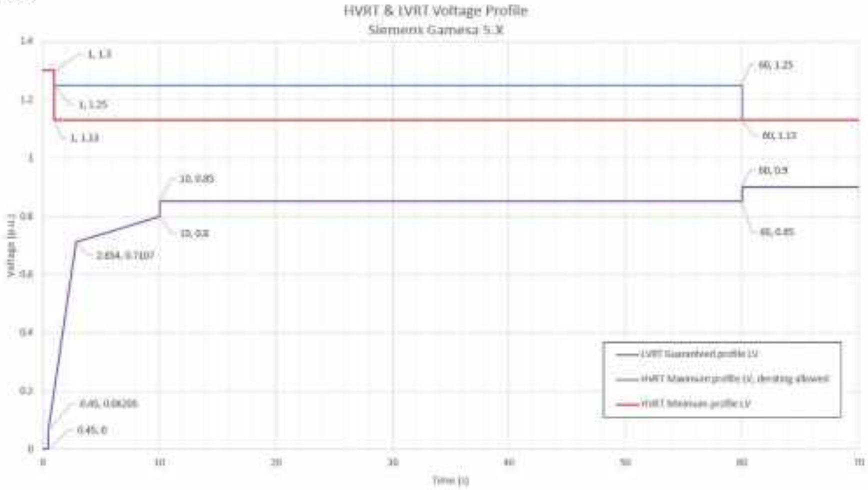

Figure 3. High and Low voltage limits for Siemens Gamesa 5.X, 50 Hz wind turbine in the range of 0-70 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

18.2. Power Factor (Reactive Power) Capability

The wind turbine can operate in a power factor range of 0.9 leading to 0.9 lagging at the low voltage side of the wind turbine transformer, considering a voltage level equal or higher of 0.95pu. Depending on the voltage behaviour (higher or lower, inside maximum permissible margins), the Reactive Power maximum capability is modified accordingly.

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The control mode for the wind turbine is with reactive power set-points or Local Voltage Control mode (external set-points of voltage).

18.3. Supervisory Control and Data Acquisition (SCADA) Capability

The SGRE SCADA system has the capability to transmit and receive instructions from the transmission system provider for system reliability purposes depending on the configuration of the SCADA system. The project specific SCADA requirements must be specified in detail for design purposes.

18.4. Frequency Capability

The wind turbine can operate in the frequency range between 46 Hz and 54 Hz, making a difference between a steady state operation (full simultaneity): ±3%, and transients' events (limited simultaneity): ±8%, over rated frequency.

Simultaneities of main operation parameters shall be considered for evaluating the permitted operation ranges, mainly:

- Active Power level
- Reactive Power provision
- Ambient Temperature
- Voltage level of operation
- Frequency level of operation

And the total time that the turbine is operating under such conditions.

18.5. Voltage Capability

The voltage operation range for the wind turbine is between 85% and 113% of nominal voltage at the low voltage side of the wind turbine transformer. The voltage can be up to 130% for 1s, see Figure 1. The wind turbine's target voltage shall stay between 95% and 105% to support the best possible performance by staying within the operation limits.

Beyond ±10% of voltage deviation, automatic voltage support algorithms could execute Reactive Power control, to secure a continuous operation of the Wind Turbine Generator and maximizing the availability, overriding external control and setpoints of Reactive Power.

18.6. Flicker and Harmonics

Flicker and Harmonics values will be provided in the power quality measurement report extract in accordance with IEC 61400-21 Edition 2.

18.7. Reactive Power -Voltage Control

The power plant controller can operate in four different modes:

- Q Control – In this mode reactive power is controlled at the point of interconnection, according to a reactive power reference
- V Control – Voltage is directly controlled at the point of interconnection, according to a voltage reference

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- V-Q static – Voltage is controlled at the point of interconnection, by means of a pre-defined voltage – reactive power characteristic
- Power factor (cosphi) control – Power factor is controlled at the point of interconnection, according to a power factor reference

The SCADA system receives feedback/measured values from the Point of Interconnection depending on the control mode it is operating. The wind power plant controller then compares the measured values against the target levels and calculates the reactive power reference. Finally, reactive power references are distributed to each individual wind turbine. The wind turbine's controller responds to the latest reference from the SCADA system and will generate the required reactive power accordingly from the wind turbine.

18.8. Frequency Control

The frequency control is managed by the SCADA system together with the wind turbine controller. The wind power plant frequency control is carried out by the SCADA system which distributes active power set-points to each individual wind turbine, to the controllers. The wind turbine controller responds to the latest reference from the SCADA system and will maintain this active power locally.

18.9. Summary of Grid Connection Capabilities

Characteristic	Value	Comments
Rated Voltage	690V	
Maximum Voltage Range	+13% -15%	Q & P deratings due to V-f Simultaneities could apply
Rated Frequency	50 / 60 Hz	
Maximum Frequency Range	± 8%	Q & P deratings due to V-f Simultaneities could apply
Rated Power Factor	0.9 Under & Over excited	Rated point reachable at Full Power, V = 0.95, f = ±3% Applicable to any AM and turbine variant
Minimum SCR at WTG MV Terminals	V-Direct: ≥ 2.0* Q-Direct: ≥ 3.0**	See note 1.
Minimum X/R at WTG MV Terminals	3.0	
Max. Frequency gradient (ROCOF)	≤ 4 Hz/s	
Allowable Max Negative Sequence Voltage	≤ 5%	
Voltage support after FRT recovery	3s	Configurable by parameter
Power recovery to 95% of Pre- Fault value	< 1000ms	Standard Configuration. Configurable by parameters adjustment.
Voltage support during FRT	Available	Configurable by parameter
Active current priority during Voltage Dip	Available	Configurable by parameter
Active Power damping after Dip	±5% pre-fault level in <2s	Can be affected if Power Recovery Ramps after Voltage Dip is modified
I_Q Injection Curve during FRT	k = [2 – 6]	Configurable by parameters
I_Q Response Time (FRT)	≤ 30ms	+20ms for 1 cycle RMS calculation
I_Q Settling Time (FRT)	≤ 60ms	+20ms for 1 cycle RMS calculation

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		-10% +20% required step
Active Power Ramp	± 6% Prated / s	Standard
Active Power Ramps - Fast Mode	+12,5% Prated/s -25% Prated/s	When commanded by SCADA
Reactive Power Ramp	±5000 kVAr/s	Configurable by parameter

Note 1.
* SCR ratio can be reduced further if Active Power recovery ramps are limited to a certain value, that secures stable operation, after voltage dip events.

** SCR ratio can be reduced further if Reactive Power Management configuration is done correctly by means of detailed grid studies, trying to avoid voltage saturation extremes in any case (over and under voltage saturation levels).

All data are subject to tolerances in accordance with IEC.

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19. Grid Performance Specifications – 60 Hz

This document describes the grid performance of the Siemens Gamesa 5.X, 60 Hz wind turbine. Siemens Gamesa Renewable Energy (SGRE) will provide wind turbine technical data for the developer to use in the design of the wind power plant and the evaluation of requirements compliance. The developer will be responsible for the evaluation and ensuring that the requirements are met for the wind power plant.

The capabilities described in this document assume that the electrical network is designed to be compatible with operation of the wind turbine. SGRE will provide a document with guidance to perform an assessment of the network's compatibility.

19.1. Fault Ride Through (FRT) Capability

The wind turbine is capable of operating when voltage transient events occur on the interconnecting transmission system above and below the standard voltage lower limits and time slot according to Figure 1 and Figure 2.

This performance assumes that the installed amount of wind turbines is in the right proportion to the strength of the grid, which means that the short circuit ratio (Sk/Sn) and the X/R ratio of the grid at the wind turbine transformer terminals must be adequate.

Evaluation of the wind turbine's fault ride through capability in a specific system must be based on simulation studies using the specific network model and a dynamic wind turbine model provided by SGRE. This model is a reduced order model, suitable for balanced simulations with time steps between 4-10 ms.

The standard voltage limits for the Siemens Gamesa 5.X, 60 Hz wind turbine are presented in Figure 1 between 0 - 70 seconds.

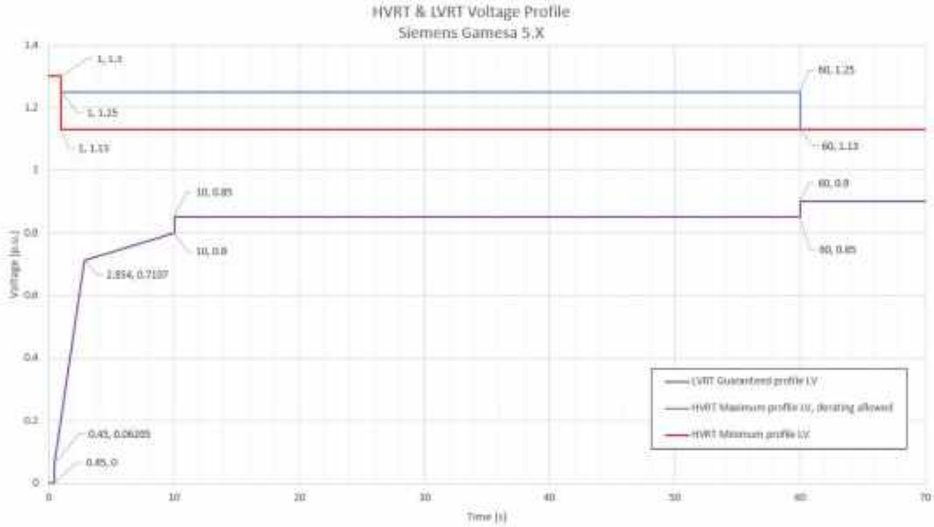

Figure 4. High and Low voltage limits for Siemens Gamesa 5.X, 60 Hz wind turbine in the range of 0-70 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

19.2. Power Factor (Reactive Power) Capability

The wind turbine can operate in a power factor range of 0.9 leading to 0.9 lagging at the low voltage side of the wind turbine transformer, considering a voltage level equal or higher of 0.95pu. Depending on the voltage behaviour (higher or lower, inside maximum permissible margins), the Reactive Power maximum capability is modified accordingly.

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The control mode for the wind turbine is with reactive power set-points or Local Voltage Control mode (external set-points of voltage).

19.3. Supervisory Control and Data Acquisition (SCADA) Capability

The SGRE SCADA system has the capability to transmit and receive instructions from the transmission system provider for system reliability purposes depending on the configuration of the SCADA system. The project specific SCADA requirements must be specified in detail for design purposes.

19.4. Frequency Capability

The wind turbine can operate in the frequency range between 55.2 Hz and 64.8 Hz, making a difference between a steady state operation (full simultaneity): ±3%, and transients' events (limited simultaneity): ±8%, over rated frequency.

Simultaneities of main operation parameters shall be considered for evaluating the permitted operation ranges, mainly:

- Active Power level
- Reactive Power provision
- Ambient Temperature
- Voltage level of operation
- Frequency level of operation

And the total time that the turbine is operating under such conditions.

19.5. Voltage Capability

The voltage operation range for the wind turbine is between 85% and 113% of nominal voltage at the low voltage side of the wind turbine transformer. The voltage can be up to 130% for 1s, see Figure 1. The wind turbine's target voltage shall stay between 95% and 105% to support the best possible performance by staying within the operation limits.

Beyond ±10% of voltage deviation, automatic voltage support algorithms could execute Reactive Power control, to secure a continuous operation of the Wind Turbine Generator and maximizing the availability, overriding external control and setpoints of Reactive Power.

19.6. Flicker and Harmonics

Flicker and Harmonics values will be provided in the power quality measurement report extract in accordance with IEC 61400-21 Edition 2.

19.7. Reactive Power -Voltage Control

The power plant controller can operate in four different modes:

- Q Control – In this mode reactive power is controlled at the point of interconnection, according to a reactive power reference
- V Control – Voltage is directly controlled at the point of interconnection, according to a voltage reference
- V-Q static – Voltage is controlled at the point of interconnection, by means of a pre-defined voltage – reactive power characteristic
- Power factor (cosphi) control – Power factor is controlled at the point of interconnection, according to a power factor reference

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The SCADA system receives feedback/measured values from the Point of Interconnection depending on the control mode it is operating. The wind power plant controller then compares the measured values against the target levels and calculates the reactive power reference. Finally, reactive power references are distributed to each individual wind turbine. The wind turbine's controller responds to the latest reference from the SCADA system and will generate the required reactive power accordingly from the wind turbine.

19.8. Frequency Control

The frequency control is managed by the SCADA system together with the wind turbine controller. The wind power plant frequency control is carried out by the SCADA system which distributes active power set-points to each individual wind turbine, to the controllers. The wind turbine controller responds to the latest reference from the SCADA system and will maintain this active power locally.

19.9. Summary of Grid Connection Capabilities

Characteristic	Value	Comments
Rated Voltage	690V	
Maximum Voltage Range	+13% -15%	Q & P deratings due to V-f Simultaneities could apply
Rated Frequency	50 / 60 Hz	
Maximum Frequency Range	± 8%	Q & P deratings due to V-f Simultaneities could apply
Rated Power Factor	0.9 Under & Over excited	Rated point reachable at Full Power, V = 0.95, f = ±3% Applicable to any AM and turbine variant
Minimum SCR at WTG MV Terminals	V-Direct: ≥ 2.0* Q-Direct: ≥ 3.0**	See note 1.
Minimum X/R at WTG MV Terminals	3.0	
Max. Frequency gradient (ROCOF)	≤ 4 Hz/s	
Allowable Max Negative Sequence Voltage	≤ 5%	
Voltage support after FRT recovery	3s	Configurable by parameter
Power recovery to 95% of Pre- Fault value	< 1000ms	Standard Configuration. Configurable by parameters adjustment.
Voltage support during FRT	Available	Configurable by parameter
Active current priority during Voltage Dip	Available	Configurable by parameter
Active Power damping after Dip	±5% pre-fault level in <2s	Can be affected if Power Recovery Ramps after Voltage Dip is modified
I_Q Injection Curve during FRT	k = [2 – 6]	Configurable by parameters
I_Q Response Time (FRT)	≤ 30ms	+20ms for 1 cycle RMS calculation
I_Q Settling Time (FRT)	≤ 60ms	+20ms for 1 cycle RMS calculation -10% +20% required step
Active Power Ramp	± 6% Prated / s	Standard
Active Power Ramps - Fast Mode	+12,5% Prated/s -25% Prated/s	When commanded by SCADA
Reactive Power Ramp	±5000 kVAr/s	Configurable by parameter

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Note 1.
* SCR ratio can be reduced further if Active Power recovery ramps are limited to a certain value, that secures stable operation, after voltage dip events.

** SCR ratio can be reduced further if Reactive Power Management configuration is done correctly by means of detailed grid studies, trying to avoid voltage saturation extremes in any case (over and under voltage saturation levels).

All data are subject to tolerances in accordance with IEC.

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20. Reactive Power Capability - 50 & 60 Hz

This document describes the reactive power capability of Siemens Gamesa 5X, 50/60 Hz wind turbines during active power production. Siemens Gamesa 5.Xwind turbines are equipped with a B2B Partial load frequency converter which allows the wind turbine to operate in a wide power factor range.

The maximum amount of Reactive Power to be generated or consumed depends on a wide range of parameters, some of them not possible to consider in a general way as they are fully dependent on the site, grid and Wind Turbine operation conditions.

Between others, the Reactive Power Capability at a given Operating Conditions depends on existing Active Power, internal temperature of Wind Turbine components, external ambient temperature, Grid conditions (voltage level, frequency level, etc.) and impact, thermally, in high inertial systems. So, the required operation time in worse conditions is also a parameter to be considered.

Online maximum capabilities estimation is executed by the Reactive Power Controller algorithm, to provide the possibility of maximizing the Capabilities in favorable grid and site conditions.

20.1. Reactive Power Capability. Generalities.

The estimated reactive power capability for the wind turbine at the LV side of the wind turbine transformer will be presented in the following Figures and Tables.

Figure 5 shows the reactive power capability depending on the generated Active Power at various voltages at the LV terminals, starting by 91% of rated voltage (PQV curves).

Figure 6 shows the reactive power capability depending on the voltage level (QV curve) at full power operation.

Figure 3 includes reactive power capability at no wind operating conditions.

The SCADA can send voltage references to the wind turbine in the range of 92% to 108% (references of 90% to 110% in specific cases). The wind power plant is recommended to be designed to maintain the wind turbine voltage references between 95% and 105% during steady state operation.

The included capability assume that the phase voltages are balanced (unbalance value below the maximum guaranteed, ≤ 5%) and that the grid operational frequency is nominal.

Given the uncertainties in determining the overall Wind Turbine operation state variables tolerances, the given Reactive Power Capability is subjected to a tolerance up to ± 10%.

These figures consider Wind Turbine operation around its expected generator speed for each operation condition (P-n operation curve). Extreme speed excursions caused by specific Wind gusts, up and down from standard value, may cause punctual Reactive Power restrictions due to Generator and Converter limits of voltage and currents. All this is also fully dependent on the Grid conditions of voltage level and external setpoint.

Values of Reactive Power for those operational points in between the shown curves can be calculated by means of linear interpolation.

The reactive power capability presented in this document is the net capability and accounts for the contribution from the wind turbine auxiliary system, the reactors and the existing filters.

The reactive power capability described is valid while operating the wind turbine within the limits specified in the Design Climatic Conditions.

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20.2. Operation below 90% of rated voltage

Standard operation at voltages in between 85% to 90% over rated is considered a special situation where both Reactive Power and Active Power may be de-rated depending on operation conditions of the Wind Turbine Generator.

Usually, depending on specific local regulations, Under Voltage Ride Through (UVRT) support happens in voltage values below 90% of rated voltage, so this operation case is not compatible as during UVRT support, Reactive Power is internally controlled depending on demands from applicable Grid Codes of Operation. This is also applicable during OVRT transients.

Specific studies should be executed in order to determine the operation and the possible values to be reached in such special operation cases, where and when required.

20.3. Reactive Power / Voltage limiting function

When Wind Turbine operation is close to voltage limits (under-voltage and over-voltage grid protection configured values), a specific Reactive Power / Voltage limiting function acts causing a so-called *Voltage Saturation*. The intention of this algorithm is to avoid a self-trip due to activation of over or under-voltage protections caused by Reactive Power operation of the turbine.

In the maximum configurable values of the voltage protection parameters (permanent operation, 85% and 113%):

- In case of under-voltage, the negative Reactive Power (Inductive, under-excited) is linearly limited from *No_Limit* to *0*, in the voltage range 90% to 85%.
  - ➢ The voltage used for evaluating and executing this Saturation is the minimum of the 3 phase voltages.
- In case of over-voltage, the positive Reactive Power (Capacitive, over-excited) is linearly limited from *No_Limit* to *0*, in the voltage range 112% to 113%.
  - ➢ The voltage used for evaluating and executing this Saturation is the maximum of the 3 phase voltages.

All these levels are possible to be set by parameters, depending on necessities, local requirements and as results of stability studies.

Reactive Power capabilities and curves shown in this document are generated having configured the next saturation values (values by default). This can be observed in figure 2. QV diagram.

- Under-Voltage saturation: 91% to 90% of rated voltage.
- Over-Voltage saturation: 112% to 113% of rated voltage.

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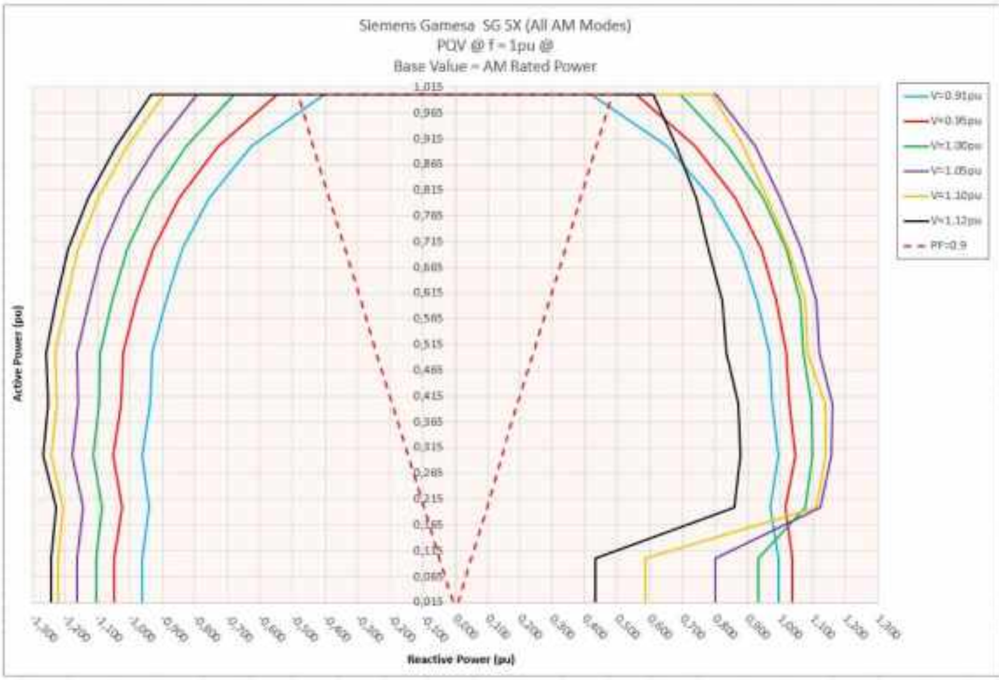

Figure 5: Siemens Gamesa 5.XReactive power capability curves (PQV), 50/60 Hz Wind Turbine, at LV terminals.

Note: Voltage Saturation set to 91% and 112% (refer to *Reactive Power / Voltage limiting function* section)

Application mode (AM)	Rating	External Nacelle Temperature
	Kw	ºC
AM 0	6600	20
AM-1	6500	23
AM-2	6400	25
AM-3	6300	28
AM-4	6200	30
AM-5	6100	33
AM-6	6000	35

Table 5: Application modes definition.

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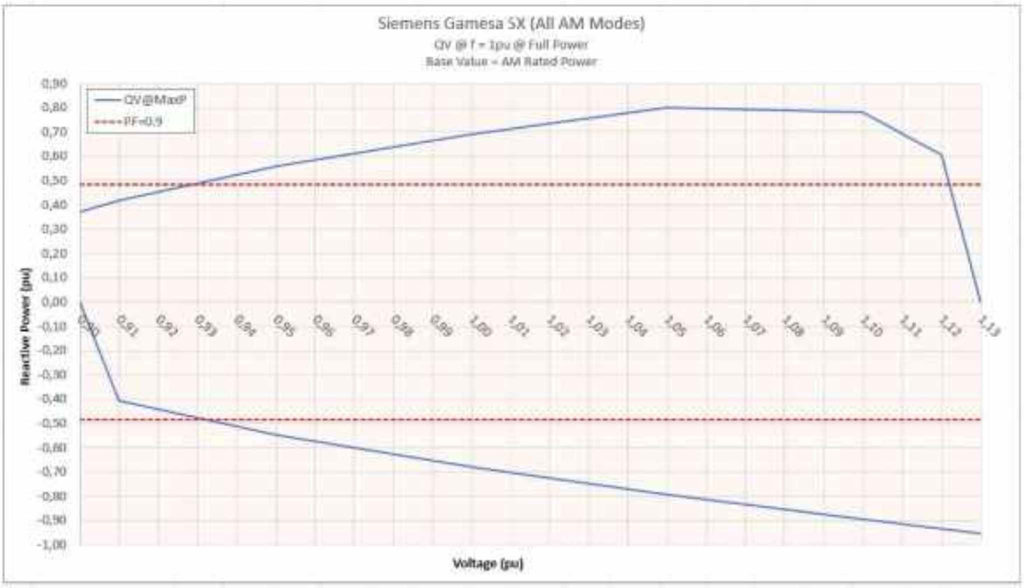

Figure 6: Siemens Gamesa 5.X→ Reactive power capability curves (QV), 50/60 Hz Wind Turbine, at LV terminals, at Full Power operation.

Note: Voltage Saturation set to 91% and 112% (refer to *Reactive Power / Voltage limiting function* section)

Base Value = AM Rated Power		Voltage (pu)							
		0,9	**0,91**	**0,95**	**1**	**1,05**	**1,1**	**1,12**	**1,13**
Active Power (pu)	**0,015***	0,985	0,997	1,038	0,933	0,803	0,586	0,433	0
	0,10	0,985	0,997	1,038	0,933	0,803	0,586	0,433	0
	0,20	0,957	0,969	1,018	1,077	1,124	1,112	0,860	0
	0,30	0,982	0,995	1,047	1,098	1,157	1,140	0,877	0
	0,40	0,962	0,975	1,029	1,095	1,160	1,139	0,873	0
	0,50	0,955	0,968	1,018	1,073	1,121	1,085	0,834	0
	0,60	0,914	0,929	0,990	1,063	1,112	1,076	0,823	0
	0,70	0,861	0,877	0,942	1,019	1,065	1,026	0,781	0
	0,80	0,770	0,789	0,862	0,949	1,001	0,962	0,742	0
	0,90	0,629	0,652	0,741	0,842	0,923	0,888	0,682	0
	1,00	0,373	0,419	0,559	0,693	0,803	0,791	0,611	0

Table 6: Siemens Gamesa 5.XReactive power capability values (pu), 50/60 Hz Wind Turbine, at LV terminals.

Capacitive / Over-excited operation.

Note: Voltage Saturation set to 91% and 112% (refer to *Reactive Power / Voltage limiting function* section)

* Case of Wind turbine operating with very low wind, but with generator connected to the grid.

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Base Value = AM Rated Power		Voltage (pu)							
		0,9	0,91	0,95	1	1,05	1,1	1,12	1,13
Active Power (pu)	0,015*	0	-0,963	-1,048	-1,105	-1,162	-1,220	-1,242	-1,253
	0,10	0	-0,963	-1,048	-1,105	-1,162	-1,220	-1,242	-1,253
	0,20	0	-0,941	-1,024	-1,085	-1,144	-1,204	-1,228	-1,241
	0,30	0	-0,962	-1,050	-1,114	-1,178	-1,241	-1,266	-1,279
	0,40	0	-0,937	-1,027	-1,093	-1,159	-1,224	-1,250	-1,263
	0,50	0	-0,930	-1,022	-1,092	-1,161	-1,230	-1,257	-1,271
	0,60	0	-0,890	-0,980	-1,054	-1,126	-1,197	-1,225	-1,239
	0,70	0	-0,839	-0,929	-1,008	-1,085	-1,160	-1,189	-1,204
	0,80	0	-0,756	-0,847	-0,934	-1,017	-1,097	-1,129	-1,144
	0,90	0	-0,629	-0,727	-0,828	-0,921	-1,009	-1,044	-1,061
	1,00	0	-0,403	-0,546	-0,679	-0,793	-0,895	-0,934	-0,953

Table 7: Siemens Gamesa 5.X→ Reactive power capability values (pu), 50/60 Hz Wind Turbine, at LV terminals. Inductive / Under-excited operation.

Note: Voltage Saturation set to 91% and 112% (refer to *Reactive Power / Voltage limiting function* section)

* Case of Wind turbine operating with very low wind, but with generator connected to the grid.

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Figure 7: Reactive Power Capability chart (pu) at no wind conditions, at LV terminals, 50/60Hz.

Case of Wind turbine not in operation, with generator stopped or below the connection speed.

Siemens Gamesa 5.X50Hz Base Value = AM Rated Power		
Voltage (pu)	**Q+ (pu)**	**Q- (pu)**
0,90	0,173	0,00
0,91	0,174	-0,146
0,95	0,182	-0,181
1,00	0,192	-0,190
1,05	0,201	-0,200
1,10	0,107	-0,209
1,12	0,074	-0,213
1,13	0,000	-0,215

Siemens Gamesa 5.X60Hz Base Value = AM Rated Power		
Voltage (pu)	**Q+ (pu)**	**Q- (pu)**
0,90	0,173	0,000
0,91	0,174	-0,146
0,95	0,182	-0,181
1,00	0,174	-0,190
1,05	0,167	-0,200
1,10	0,091	-0,209
1,12	0,061	-0,213
1,13	0,000	-0,215

Table 8: Reactive Power Capability values (pu) at no wind conditions, at LV terminals, 50/60Hz.

Case of Wind turbine not in operation, with generator stopped or below the connection speed.

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21. SCADA System Description

The SGRE SCADA system is a system for supervision, data acquisition, control, and reporting for wind farm performance.

21.1. Main features

The SCADA system has the following main features:

- On-line supervision and control accessible via secured tunnel over the Internet.
- Data acquisition and storage of data in a historical database.
- Local storage of data at wind turbines if communication is interrupted and transferred to historical database when possible.
- System access from anywhere using a standard web browser. No special client software or licenses are required.
- Users are assigned individual usernames and passwords, and the administrator can assign a user level to each username for added security.
- Email function can be configured for fast alarm response for both turbine and substation alarms. Configuration can also support alarm notification via SMS service.
- Interface to power plant control functions for enhanced control of the wind farm and for remote regulation, e.g. MW / Voltage / Frequency / Ramp rate.
- Interface for integration of substation equipment for monitoring and control.
- Interface for monitoring of Reactive compensation equipment, control of this equipment is achieved via the SGRE power plant controller
- Integrated support for environmental control such as noise, shadow/flicker, bat/wildlife and ice.
- Capabilities for monitoring hybrid power plant equipment such as Battery Energy Storage Systems (BESS) and Photo Voltaic (PV) systems. Control of such equipment is achieved via the SGRE power plant controller.
- Power curve plots and efficiency calculations with pressure and temperature correction (pressure and temperature correction available only if SGRE MET system supplied).
- Condition monitoring integrated with the turbine controller using designated server.
- Ethernet-based system with secure compatible interfaces (OPC UA / IEC 60870-5-104) for online data access.
- Legacy protocols like OPC-(XML)-DA or Modbus TCP can be supported on request
- Access to historical - scientific and optional high resolution data via Restfull API.
- Virus Protection Solution.
- Back-up & restore.

21.2. Wind turbine hardware

Components within the wind turbine are monitored and controlled by the individual local wind turbine controller (SICS). The SICS can operate the turbine independently of the SCADA system, and turbine operation can continue autonomously in case of, e.g. damage to communication cables.

Data recorded at the turbine is stored at the SICS. In the event that communication to the central server is temporarily interrupted data is kept in the SICS and transferred to the SCADA server when possible.

21.3. Communication network in wind farm

The communication network in the wind farm must be established with optical fibers. The optimum network design is typically a function of the wind farm layout. Once the layout is selected, SGRE will define the minimum requirements for the network design.

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The supply, installation, and termination of the communication network are typically carried out by the Employer. If specifically agreed the division of responsibility for the communication network can be changed.

21.4. SCADA server panel

The central SCADA server panel supplied by SGRE is normally placed at the wind farm substation or control building. The server panel comprises amongst others:

- The server is configured with standard disk redundancy (RAID) to ensure continuous operation in case of disk failure. Network equipment. This includes all necessary switches and media converters.
- UPS back up to ensure safe shut down of servers in case of power outage.

For large sites or as option a virtualized SCADA solution can be supplied.

On the SCADA server the data is presented online as a web-service and simultaneously stored in an SQL database. From this SQL database numerous reports can be generated.

Employer "client" connection to the SCADA system establishing via the internet through a point to point TCP/IP VPN-connection.

21.5. Grid measuring station and Wind Farm Controller

The SCADA system includes a grid measuring station located in one / more module panels or in the SCADA server panel. Normally the grid measuring station is placed at the wind farm substation or control building.

The heart of the grid measuring station is a PQ meter. The Wind Farm Control /grid measuring station can be scaled to almost any arrangement of the grid connection. The grid measuring station requires voltage and current signals from VT's and CT's fitted at the wind farm PCC to enable the control functions.

The grid measuring station and the Wind Farm Control interfaces to the SGRE SCADA servers and turbines are via a LAN network.

The Wind Farm Control can on request be supplied in a high availability (HA) setup with a redundant server cluster configuration.

Note: In small SGRE SCADA systems (typically <10 turbines) and if the small SGRE SCADA system is placed in a turbine the Wind Farm Control and grid measuring station may be arranged otherwise.

21.6. Signal exchange

Online signal exchange and communications with third party systems such as substation control systems, remote control systems, and/or maintenance systems is possible from both the module and/or the SGRE SCADA server panel. For communication with third party equipment OPC UA and IEC 60870-5-104 are supported. Legacy protocols like OPC-(XML)-DA or Modbus TCP can be supported on request

21.7. SGRE SCADA software

The normal SGRE SCADA user interface presents online and historical data. The screen displays can be adjusted to meet individual customer requirements.

Historical data are stored in an MS SQL database as statistical values and can be presented directly on the screen or exported for processing in MS Access or via a RESTfull API.

The SGRE SCADA software can also serve as user interface to the Wind Farm Control functions.

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21.8. Virus protection solution

A virus protection solution can be offered as a part of the Service Agreement (SA). An anti-virus client software will in that case be installed on all MS-Windows based components at the SCADA system and the WTGs.

The virus protection solution is based on a third-party anti-virus product. Updates to the anti-virus client software and pattern files are automatically distributed from central SGRE based servers.

21.9. Back-up & restore

For recovery of a defect SCADA system or component, the SGRE SCADA system provides back-up of configuration files and basic production data files. Both configuration and selected production data are backed up automatically on a regular time basis for major components. The back-up files are stored both locally on the site servers and remotely on SGRE back-up storage servers.

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22. Codes and Standards

This document lists codes and standards according to which turbines are designed, manufactured and tested. The scope of this document is limited to the Siemens Gamesa 5.X platform.

SGRE Onshore geared turbines are designed, manufactured, and tested to SGRE's technical drawings, procedures, and processes that are generally in compliance with the applicable sections of the codes and standards listed herein. This list of codes and standards for design, manufacturing, and testing forms a part of the design basis documentation. The edition of the codes and standards is the version used for the certification process which is conducted by an external certifying body.

22.1. GENERAL

- IEC-RE Operational Document: OD-501, Type and Component Certification Scheme*
- IEC 61400-5:2020 Wind energy generation systems - Part 5: Wind turbine blades
- IEC 61400-6:2020 Wind energy generation systems - Part 6: Tower and foundation design requirements
- *IEC 61400-1:2019 Ed.4 Wind turbines –. Part 1: Design requirements*
- IEC 61400-11:2012/AMD1:2018 Amendment 1 - Wind turbines - Part 11: Acoustic noise measurement techniques
- *IEC 61400-12-1:2017, Ed.1, Wind Turbine Generator Systems Part 12-1: Power performance measurements of electricity producing wind turbines*
- *IEC 61400-13: 2015 Wind Turbine Generator Systems - Part 13: Measurement of Mechanical Loads*
- *IEC 61400-23 Ed. 1.0 EN :2014 Wind turbines - Part 23: Full-scale structural testing of rotor blades*

- *EN 10025-1:2004, Hot rolled products of structural steels - Part 1: General technical delivery conditions*
- *EN 10025-2:2004, Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels*
- *EN 10025-3:2004, Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels*
- *EN 10029:2010, Hot rolled steel plates 3 mm thick or above - Tolerances on dimensions, shape and mass*
- *ISO 683-1:2018 Heat-treatable steels, alloy steels and free-cutting steels. Non-alloy steels for quenching and tempering*
- *EN 1563:2018, Founding - Spheroidal graphite cast irons*
- *EN 1993-1-8:2005/AC:2009: Eurocode 3: Design of steel structures Part 1-8: Joints*
- *EN 1999-1-1-2008 Design of aluminum structures – part 1-1: General structural rules*

- *ISO 16281:2008 Rolling bearings - Methods for calculating the modified reference rating life for universally loaded bearings*
- *ISO 16281:2008 / Cor. 1:2009 Rolling bearings - Methods for calculating the modified reference rating life for universally loaded bearings*
- *ISO 281:2007 Rolling bearings - Dynamic load ratings and rating*
- *ISO 76:2006/Amd 1:2017 Rolling bearings – Static load ratings AMENDMENT 1*
- *ISO 898-1:2013, Mechanical properties of fasteners made of carbon steel and alloy steel -- Part 1: Bolts, screws and studs with specified property classes -- Coarse thread and fine pitch thread*
- *VDI 2230 Blatt 1, 2016, Systematic calculation of highly stressed bolted joints - Joints with one cylindrical bolt*
- *ISO 4413:2010 Hydraulic fluid power -- General rules and safety requirements for systems and their components*

- *DIN 51524-3:2017 Pressure fluids - Hydraulic oils - Part 3: HVLP hydraulic oils, Minimum requirements*

- *ISO 16889:2008 + A1:2018 Hydraulic fluid power -- Filters -- Multi-pass method for evaluating filtration performance of a filter element*
- *UNE-EN 14359:2008+A1:2011: Gas-loaded accumulators for fluid power applications.*
- *PED 2014/68/EU Pressure Equipment Directive*

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- *DNV-DS-J102:2010 Design and Manufacture of Wind Turbine Blades, Offshore and Onshore Wind Turbines*
- *DIBt - Richtlinie für Windenergieanlagen - Oktober 2012, korrigierte Fassung März 2015*
- *DIBt* – Richtlinie für Windenergieanlagen:2012, Einwirkungen und Standsicherheitsnachweise für Turm und Gründung.

22.2. GEARBOX

- *IEC 61400-4:2012 Wind turbines -- Part 4: Design requirements for wind turbine gearboxes*

22.3. ELECTRICAL

- *IEC 61400-21-1:2019 Wind energy generation systems - Part 21-1: Measurement and assessment of electrical characteristics - Wind turbines*
-
- *IEC 61400-24:2019 Wind energy generation systems - Part 24: Lightning protection*
-
- *IEC* 60076-16:2018 – Power transformers - Part 16: Transformers for wind turbine applications
- *IEC 60204-1:2016 Safety of machinery - Electrical equipment of machines - Part 1: General requirements*
- IEC 61000-6-2:2016 Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments
- IEC 61000-6-4:2018 Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments
- IEC 61439-1:2020 Low-voltage switchgear and controlgear assemblies – Part 1: General rules
- IEC 61439-2:2020 Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies
- *Low Voltage Directive 2014/35/EU*
- *EMC Directive* 2014/30/EU

22.4. QUALITY

- ISO 9001:2015 Quality management systems – Requirements

22.5. PERSONAL SAFETY

- 2006/42/EC Machinery Directive
- EN 50308:2004, Wind turbines – Protective measures – Requirements for design, operation and maintenance.
- OSHA 2005 Requirements for clearances at doorways, hatches, and caged.
  - OSHA's Subpart D Walking-Working Surfaces Section 1910.27v
- ISO12100:2011 Safety of machinery – General principles for design – Risk assessment and risk reduction
- ISO 13849-1:2015 – Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
- ISO 13849-2:2013 - Safety of machinery – Safety-related parts of control systems – Part 2: Validation

22.6. CORROSION

- *ISO 12944-1:2017, Paints and varnishes - Corrosion protection of steel structures by protective paint systems – Part 1: General introduction (class C3 to C4)*

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23. Ice Detection System and Operations with Ice

Siemens Gamesa Renewable Energy's (SGRE) Ice detection and Operation with Ice system offers functionality that extends the range of operation during ice conditions. The main configurable options determine if maximum production or maximum safety is required.

The following options for ice detection sources can be used:

- Low power detection curve (LPDC)
- No cut-in detection
- **Optional extra:** External sensor detection, nacelle- or blade-based.

Once ice has been detected through any of the selected sources the following ice detection response is handled by the Operation with Ice strategy where the following options are available:

- Stop the turbine, either awaiting automatic reset or manual reset
- Stop the turbine, combined with yawing to a specific angle
- Adaptive Operation, continued operation optimizing the power

Figure 1 shows a visualization of the available options and how they are connected.

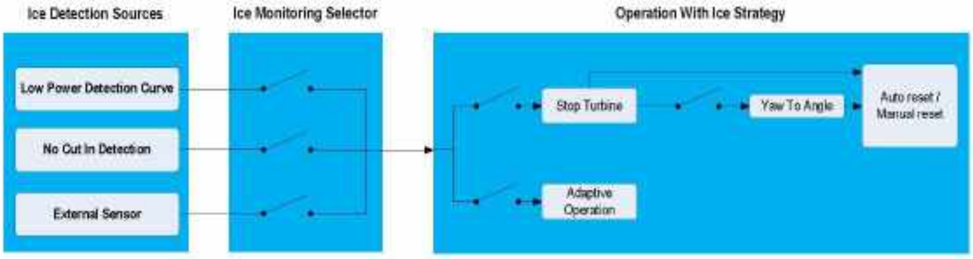

Figure 1: Ice Detection and Operation with Ice Strategy interface for individual turbines

> *i* Adaptive Operation used as the Operation With Ice strategy requires the Low Power Detection Curve and No Cut In Detection to be used, it is therefore not compatible with the external sensor.

Ice build-up on the turbine can possibly cause damage to objects and people in the vicinity. The ice detection and Operation with Ice system will not protect against ice being thrown from the turbine(s). What the system does is either optimize performance and yield maximum production despite ice on the turbine or stop the turbine to prevent operating with ice. There may be ice on blades upon start and/or stop of the turbine. It is the sole responsibility of the owner of the turbine to ensure that the public is protected from ice being thrown from the turbine. The Owner must always ensure that the operation of the turbine complies with all restrictions applicable to the turbine, irrespective of whether such restrictions follows from permits, legislation or otherwise. SGRE accepts no responsibility for any violation of requirements.

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23.1. Ice Detection Sources

23.1.1. Low Power Detection Curve (LPDC)

The LPDC functionality is an integrated part of the turbine controller, thus not requiring additional sensors.

LPDC is a requirement to be active when the *Operation with Ice Strategy: Adaptive* is selected.

LPDC detects ice when power production degrades due to ice build-up on the blades during operation when the turbine produces power in cold weather by comparing the actual power production to the sales power curve shown in Figure 2 when the ambient temperature is below 5° C (configurable). LPDC is based on a percentage of the sales power curve with a minimum separation to the sales power curve.

If production falls below the "LPDC Ice Detection" (Blue) curve shown in Figure 2, the selected Operation with Ice strategy is activated.

If *Operation with Ice Strategy: Adaptive Operation* is selected and the production increases above the "LPDC Ice Detection" curve, Adaptive Operation is deactivated.

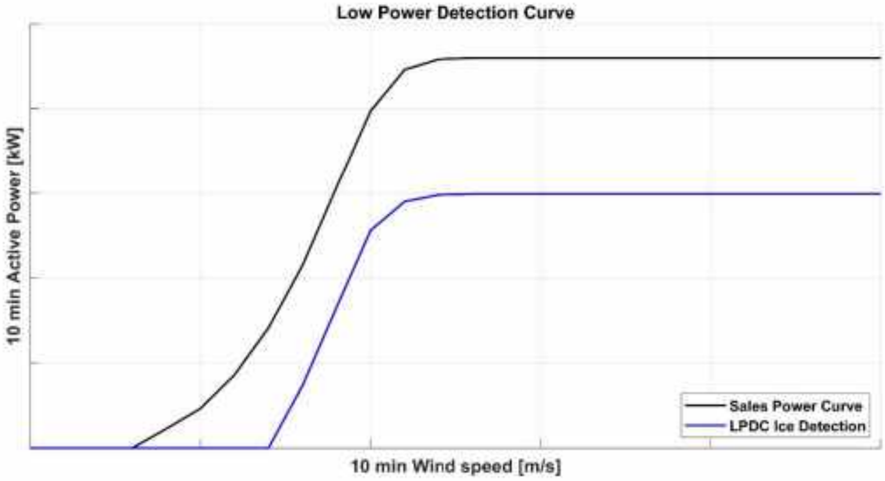

Figure 2: Illustration of Low Power Detection Curve (LPDC)

23.1.2. No Cut-in

The No Cut-in functionality is an integrated part of the turbine controller, thus not requiring additional sensors. No Cut-in is a requirement to be active when *Operation with Ice Strategy: Adaptive Operation* is configured.

No Cut-in is an ice detection method that indicates when there is enough wind for the wind turbine to produce power, but the turbine is unable to cut-in, connect to the grid, and produce power for a period of time due to severe ice build-up in cold weather.

If Operation with Ice Strategy: Adaptive Operation is selected as the ice detection response strategy, the turbine will cut-in and connect to the grid at an adapted power production level given the conditions. See further below in chapter "Operation with Ice Strategy: Adaptive Operation".

23.1.3. External Sensor Options

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The external ice detector sensor functionality is an optional extra system that can be used to create a response directly from the sensor on the turbine. Most often the sensor reports data to SCADA which controls the turbines at the site with respect to stopping them. It is intended for installation on wind turbines located in areas where there is a risk that ice can build up on either the turbine nacelle or blades and there are personal safety or legislation concerns that required the turbine to be stopped instantly when ice is detected. Compared to the LPDC and No Cut-in ice detection source options are designed to detect when performance is impacted where ice may already exist on the turbine.

The external sensor is only compatible with Operation with Ice Strategy:

- Stop the turbine
- Stop the turbine, yawing to a specific angle

The external sensor communicates with the Supervisory Control and Data Acquisition (SCADA) system. Typically, only a few external sensors are installed on a given site, and SCADA can be configured to stop the entire site or clusters or individual turbines if deemed necessary.

There are two separate types of use for the external sensor:

- External sensor is selected as the turbines ice detection source (Figure 1) for individual turbines, which allows the individual turbine itself to react to the sensor. Additionally, SCADA can still react to the signal and stop turbine(s) at the site.
- External sensor is not selected as the turbines ice detection source (Figure 1), so the individual turbine itself will not react to the external sensor, but SCADA can still react to the signal and stop turbine(s) at the site.

23.1.4. External Sensor Types

23.1.5. Nacelle Based Ice Detection Sensor (Optional)

The nacelle ice detection sensor is an optional system intended for installation on wind turbines located in areas where ice can build up on the turbine. The purpose of the ice detector system is to provide the turbine controller information about potential risk for ice on the turbine. The ice detection system can detect in-cloud icing as well as freezing rain. Depending on requirements when ice is detected an ice alarm can initiate a turbine stop.

The system can come with a valid certification from accredited institutes.

23.1.6. Blade-Based Ice Detection Sensor (Optional)

An additional option is to install a blade-based ice detection system. Such system includes a set of sensors (accelerometers) on each blade, plus a central monitoring unit. The ice detection is performed by analysis of blade eigenfrequencies with respect to ice accumulation. Therefore, the system needs a calibration prior to enter service (varying, and up to 3 months depending on the conditions and WTG configuration).

Ice detection is possible at standstill and during operation. No minimum rotation per minute (rpm) is required, however a minimum wind speed of 2 m/s is required to ensure sufficient excitation of blade.

The system can also come with a valid certification from accredited institutes.

23.1.7. Options and logging in SCADA

Possible options in SCADA to configure the usage of the external sensor on site level (independent of the individual turbine interface):

- Set predefined ice conditions using ice parameters
- Enable or disable automatic stop of individual turbines
- Enable or disable automatic restart of individual turbines
- Group turbines for auto stop and auto restart. SGRE recommends using SCADA to group ice sensor installed

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turbines along with turbines on which ice sensors are not installed.

Ice parameters are set in the SCADA interface. Depending on requirements, ice parameters can be modified to configure new ice conditions through the SCADA interface. Below is a list of the parameters:

- **Ice Restart Delay:** Turbines that are stopped due to ice are restarted only if ice is not reported from the sensor during the "Ice Stop Delay" in seconds configured by the user.

- **Ice Stop Delay:** Turbines are stopped due to ice only if ice is detected on turbine(s) for more than the ice stop delay in seconds configured by the user.

- **Ambient Temperature Duration:** Duration in seconds for how long the ambient temperature for ice detection should be exceeded to restart the turbines which are stopped due to ice.
  - E.g. above 5°C for <u>600 seconds</u>

- **Ambient Temperature Threshold:** This parameter defines the temperature which must be exceeded to restart turbines stopped due to ice detection.
  - E.g. above <u>5°C</u> for 600 seconds

- **Ice Control Start Time** and **Ice Control End Time:** Configured turbines will be stopped due to ice detection when the actual time is between Ice Control Start Time and Ice Control End Time. When the current time falls outside the range specified in Ice Control Start Time and Ice Control End Time, the turbines are restarted.

The alarms are presented in the 'Alarm log' of the Web WPS SCADA interface.

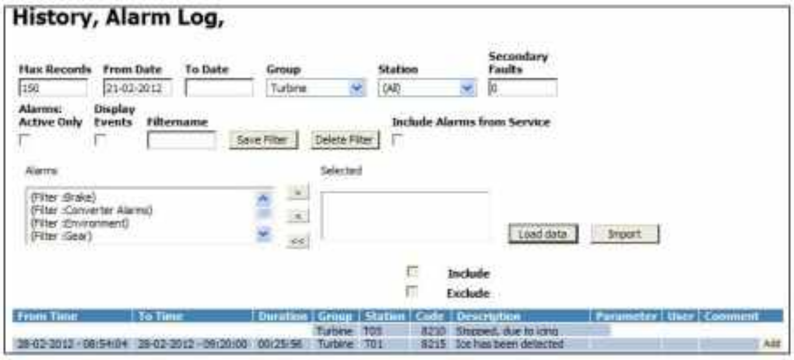

Figure 3 - Presentation of alarms related to the ice detection system in Web WPS SCADA

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23.2. Operation with Ice Strategy

23.2.1. Operation with Ice Strategy: Stop Turbine

Stopping the turbine is often used in scenarios where it is not safe to keep running the turbine during icing conditions, e.g. where potential wildlife, people or equipment can be damaged/hurt. Only if using the external sensor can this approach be seen as safe, as the external sensors are often mounted on the nacelle and will detect when ice is forming and not based on production as the "Low Power Curve Detection" and "No Cut In" features do.

Operation with Ice Strategy: Stop Turbine makes sure the turbine is stopped when ice is detected. Additional option is possible in combination with the stop: Yaw to Angle.

Regardless of how *Operation with Ice Strategy: Stop Turbine* is configured, it is possible to determine if the turbine should auto reset or manually reset. The following options exist for auto reset:

- A stopped turbine with an ice detection alarm is reset after X hours
- A stopped turbine with an ice detection alarm requires manual reset
- A stopped turbine with an ice detection alarm that is yawed to a specific angle due to safety constraints is reset after X hours
- A stopped turbine with an ice detection alarm that is yawed to a specific angle due to safety constraints requires manual reset

23.2.2. Operation with Ice Strategy: Adaptive Operation

Operation with Ice Strategy: Adaptive Operation provides customers with a way to optimize the wind turbine so that it continues operation when ice builds up on the blades and ice detection is triggered, thereby limiting shutdown events. By allowing continued operation, ice accumulates more slowly on the blades compared to if it were at a standstill. Therefore, the yield of production with ice buildup will increase due to adaptation/optimization to icing conditions through pitch angle and speed-power modification.

Operation with Ice Strategy: Adaptive Operation offers a limited power production under managed loads and thereby reduces the turbines' shutdown events. *Operation with Ice Strategy: Adaptive Operation* is a wind turbine controller software functionality for optimizing performance, allowing the turbine to maintain operation in ice conditions.

When ice is detected via the LPDC or No Cut-in ice detection sources, *Operation with Ice Strategy: Adaptive Operation* finds the optimal operational setup in order to maximize production by first modifying the speed power curve (as shown in Figure 4). *Operation with Ice Strategy: Adaptive Operation* increases the rotor speed to avoid the blades stalling and the turbine from cutting out. The speed will not exceed nominal speed.

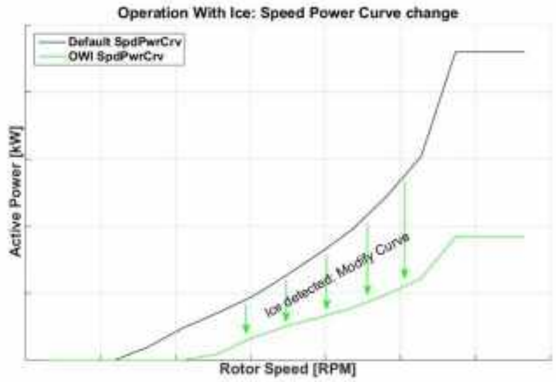

Figure 4: Illustration of OWI Speed-Power curve modification

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Use of the *Operation with Ice Strategy: Adaptive Operation* functionality may under certain conditions increase the noise emissions from the turbine, and the noise emissions may exceed the levels indicated in the turbine supply agreement. Any noise levels indicated or warranted in the turbine supply agreement shall not be applicable in the event of operation of the turbine with the *Operation with Ice Strategy: Adaptive Operation* functionality activated.

It is the sole responsibility of the owner of the turbine to ensure that the turbine operating with *Operation with Ice Strategy: Adaptive Operation* functionality activated complies with any noise restriction applicable, irrespective of whether such limits follow from permits, legislation or otherwise. Siemens Gamesa accepts no responsibility for any violation of such limits.

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2.2. CARACTERÍSTICAS DE VIALES Y PLATAFORMAS APARA AEROGENERADORES SG 6.6 170

(Utilizadas como base para la obra civil del proyecto.)

Table of contents

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1. Aim and scope

The aim of this specification is to describe the minimum geometrical requirements of the roads and hardstands required for a safe component transportation and assembly of the wind turbines. Additionally, it includes the minimum deliverables that will be needed from SGRE to start with the transportation and erection works. The scope includes all W.F. with the following WTG models and erection strategies:

Tower	No. of tubular steel section	Power	Blade
T100	4	6.6	SG170
T110.5	6	6.6	
T115	5	6.6	
T135	6	6.6	
T145	6	6.6	
T150	7	6.6	
T155	7	6.6	
T165	8	6.6	
T165MB	2	6.6	

Table 1. WTG models

Tower	STG3	STG4 (SGRE Standard)
T100	✔	✔
T110.5	✔	✔
T115	✔	✔
T135	✔	✔
T145	✔	✔
T150	✔	✔
T155	✔	✔
T165	✔	✔
T165MB	✔	✔

Table 2. SGRE strategies

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Strategy	Nacelle	DT	Hub	Blade
Strategy 3	Modular 	DT/Hub 		Blade To Blade (SBI) 
Strategy 4	Modular 	DT 	Hub 	BladeTo Blade (SBI) 

Table 3. Components of each strategy

Note:

This specification sets a guide to be followed for the design and construction of a wind farm civil engineering project. The project undertaken in accordance with this specification must be reviewed and approved by SGRE prior to execution. However, the civil designer is solely responsible for making sure that the design complies with this specification, the contract requirements and local norms and standards.

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2. Definitions and acronyms

Acronyms	Definition
SGRE	Siemens Gamesa Renewable Energy
Main crane	Capable of lifting any component to the highest point of the wind turbine.
Pre-installation crane	Used for installing elements at the lower part of the tower.
Tailing crane	Supports the main and pre-installation crane for mounting and unloading components.
Mobile crane	Telescopic mobile crane
	Lattice boom mobile crane
NTC	Narrow-Track Crawler Crane
WTC	Wide-Track Crawler Crane
Intermediate hardstand	The work area for wind turbine assembly is parallel and close to the internal roads of the wind farm.
End-of-road hardstand	Work area for wind turbine assembly at the end of internal wind farm roads.
Wind farm access roads	These roads do not pass by asphalt roads and they are used to transport components and disassembled cranes.
Wind farm internal roads	Roads that pass between wind turbines for the transportation of components and with the capacity for transporting cranes.
SP	Standard Proctor
MP	Modified Proctor
WTG	Wind Turbine Generator

Table 4. Acronyms and definitions

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3. Description

3.1. Roads

3.1.1. Reference legislation

The legislation of the corresponding country on the design of civil engineering must be applied. If there is no such legislation, the legislation given as a reference in the annexes should be followed as a guide.

3.1.2. Design of the windfarm internal roads

In case there is no legislation for the road design the dimensioning of the road pavement should be based on the AASHTO method for roads with a low volume of traffic (Part 2, Chapter 4). This methodology is based on an empirical formula that relates the characteristics of the pavement layers with their performance, in order to determine whether the road pavement section will be capable of bearing the traffic loads to which it will be applied.

The design of the road and the geotechnical report will be provided to Siemens Gamesa together with the quality control of the roads during the handover of the civil works and before starting with the transportation and the erection process.

3.1.3. Road composition and structure

Wind farm access roads must support a **minimum load** of 12t per axle corresponding to the transportation of wind turbine elements and crane elements.

Internal wind farm roads must support a **minimum load** of:

- Without mounted crane movement:
  - 1.4 kg per cm² in the case of crawler cranes (NTC and WTC).
  - 22.5t per axle in the case of mobile cranes.
- With mounted crane movement:
  - 2.45 kg per cm² in the case of crawler cranes (NTC and WTC).
  - 22.5t per axle in the case of lattice boom mobile cranes.
  - 24.5t per axle in the case of telescopic mobile cranes.
  - 14.7t per axle in the case of pre-installation telescopic mobile cranes.

The dimensions of the roadbed must be in accordance with the number of WTGs at the wind farm, allowing for the number of transport vehicles per WTG.

Tests must be carried out on the material used for the subgrade and for the roadbed, in order to control the compaction of the different layers and ensure that the civil works are correctly executed. The quality control and the requirements for the civil works design is defined according to the ***5.3 Quality tests and requirements for civil works plan projects.***

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With the trace material, once analyzed, suitable compaction means must be used to find a subgrade of enough elasticity modulus value. The elasticity module will be measured from the compressibility module of the second cycle of the loading plate test as per DIN 18134 (or in its absence, NLT-357), the acceptance criteria will be indicated in the road section design.

The dry density required after compaction for the different types of materials forming the roadbed is 98% of that obtained in the PM test or above.

Fill material will be compacted in layers to a maximum thickness of 30 cm to ensure the effectiveness of the machinery along the entire section.

Where expansive material (expansive clay, etc.) or loose soil conditions are indicated in the geotechnical report, the use of geosynthetics is strongly recommended (at least with the soil reinforcement and separation functions).

The elasticity module of the finished roadbed must be measured based on the compressibility module of the second cycle of the load plate test as per DIN 18134 (or in its absence, NLT-357), and the result must never be less than Ev2=80 MPa (*). Likewise, the relation between the first and second load cycle must be less than 3.

(*) In countries where the load plate is not usually used, use the following relationship to obtain the acceptance criteria for the roadbed built:

$$E = \frac{\pi \cdot (1 - v^2)}{3} \cdot Ev_2$$

- E: elasticity module
- v: Poisson's ratio
- Ev2: second plate loading test cycle compressibility module

Additionally, remember that the dry density required after compaction for the different types of materials forming the roadbed is 98% of that obtained in the MP test or above.

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3.1.4. Road width

The road width will vary for curves according to the following section 3.1.5. Curve widening – General.

Minimum road width	
A. Wind farm access road transportation of components	**As a minimum and usable 4.5m*** + 2 x 0.50m of obstacles **in straight sections.** **As a minimum and usable 5.0m*** + 2 x 0.50m free of obstacles **in curves.** **As a minimum and usable 5.5m*** + 2 x 0.50m free of obstacles in case of **reverse driving.**
B. Internal wind farm road with crane movement	**Pneumatic Crane** **As a minimum and usable 4.5m** + 2 x 0.75m free of obstacles
	WTC • Usable 12 to 14m* • 4m + 3m parallel tread (making 12 to 14 m)
	NTC **As a minimum and usable 7m**
C. Access road to the wind farm Transportation of components and Internal roads of the wind farm without crane movement. (Wind Farms in the United States)	**As a minimum and usable 5m** + 2 x 0.8m free of obstacles
Note: **Usable m (meters) - Space capable of bearing the loads to which the road will be submitted without the risk of caving-in, sliding or sinking. Furthermore, the last 50cm prior to the curbs on these roads (not included in the usable meters) are not valid for withstanding weights, due to the danger of horizontal creep of the ground. Thus, the carrier transporting the nacelle and heavy haulers in general must never go beyond these limits under any circumstances whatsoever.** **This table marks the minimum requirement for the road width as general.** **There may be more limitations on the use of road width project specific. On the one hand, the safety distances or calculation limitations on the edge of high embankments and on the other hand, the possibility of splitting the road into two parts for crawling with WTC cranes. These should be mentioned by the wind farm designer.** *Width based on crane model	

Table 5. Minimum road width in access and internal roads

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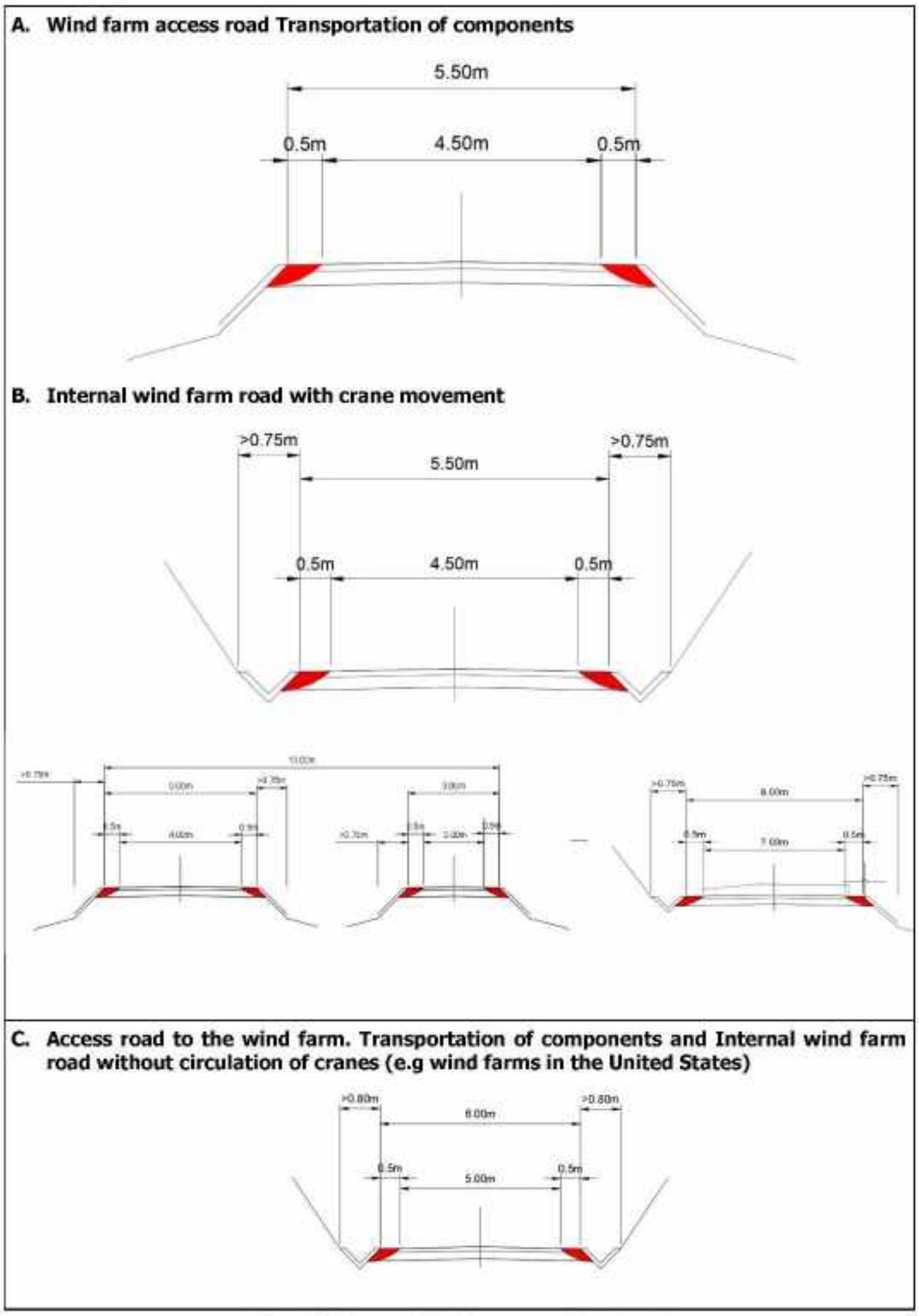

Figure 1. Minimum road width in access and internal roads

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For curves with an interior cleared profile, the inside curb of the curve must be pipelined or have a maximum depth of 10 cm.

The slope of cutting on internal roads must be limited in accordance with the wind farm's geotechnical survey and determined by the crane being used for assembly. The most restrictive case is movement of NTC without dismounting.

3.1.5. Curve widening – General

The smaller the curve radius of the alignment curve, the greater the road width must be (difference between outside and inside radius) at the curve.

Blade transportation is considered a limiting element in the calculation of curve widening.

The following example table is completed for each model with these widths:

- A: Road width
- SAE: Exterior widening
- SAI: Interior widening
- De: Entrance widening development
- Ds: Exit widening development

RADIUS - ANGLES					
	90º				
	A	SAe	SAI	De	Ds
R35	7	24	11	1	20
R40	...	...	...	...	...
R45	...	...	...	...	...

Figure 2. Curve widening

The conclusions of the study will be reflected in a table where:

- A: Road width
- SAi: Is the maximum interior sweep of the vehicle or its cargo
- SAe: Is the maximum exterior sweep of the vehicle or its cargo
- R35: Represents the radius curve at the centre of the road
- 60º: Represents the angle formed by two straight sections of road joined by a curve of a given radius

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- De: Distance from the first point of tangency to the beginning of the widening
- Ds: Distance from the end of the widening to the second point of tangency

The transport vehicles used to transport various components of the turbine up to the site should be equipped with self-steering rear axles in those countries and projects where this type of equipment is feasible.

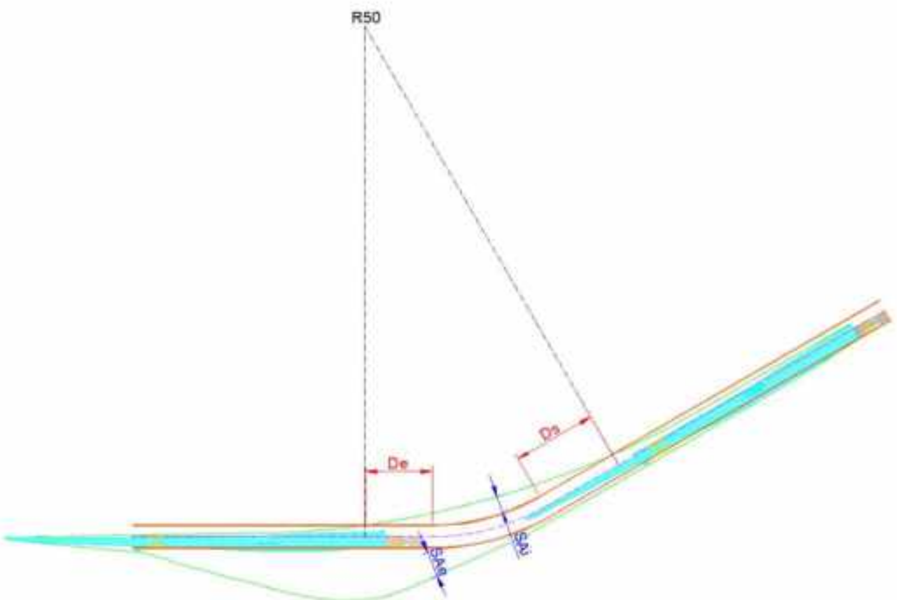
A study for guidance was make taking in to account an estimate vehicle (General vehicle). Each region will provide a study of curve radius with its most restrictive vehicles. As an example in the ***5.1 Transport requirements***, the general results analysis for turbine model is included. This example should not be used as the values are not updated.

Besides, per each specific project, inner and outer widening for each curve along the route should be studied per transport simulation.

SGRE has available curve widening table for each region with a generic transport, which should be validated project by project.

Below are three examples to follow for the definition of curve widening. Final drawings are to be submitted by the region.

- **SG 170 Alineación a 30º y Radio 50m:**



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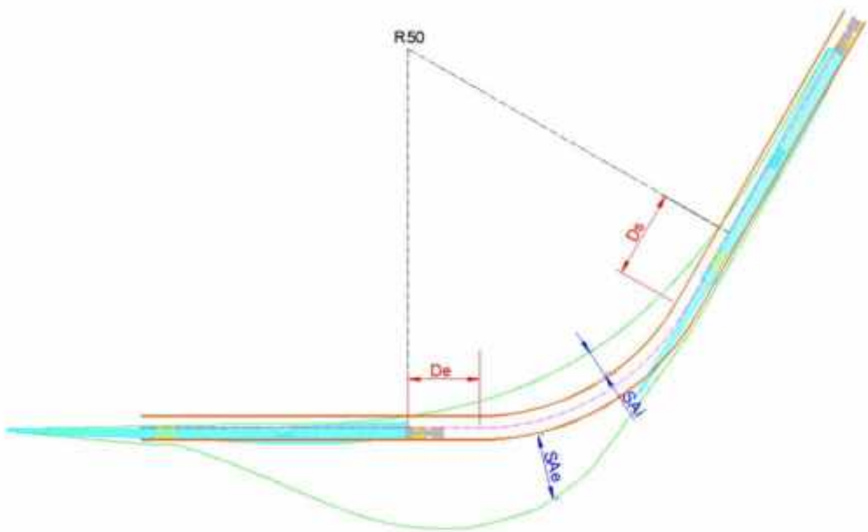
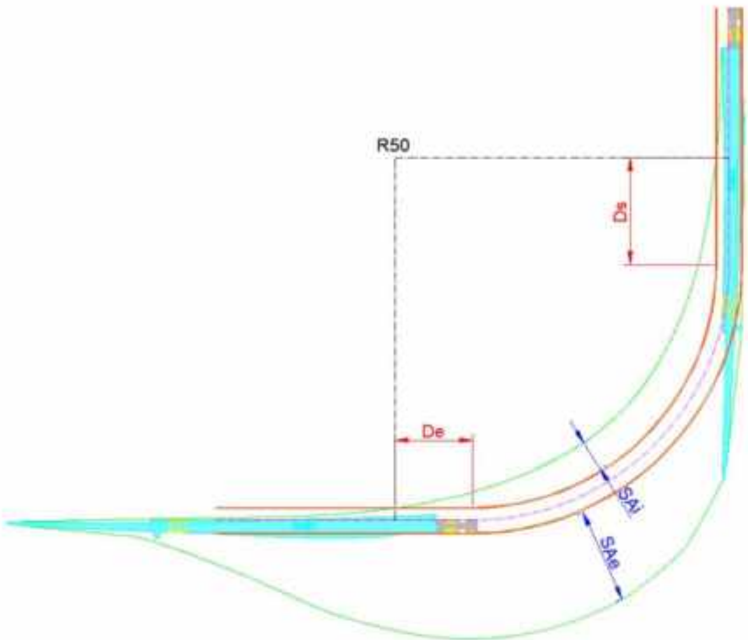
- **SG 170 Alineación a 60º y Radio 50m:**



- **SG 170 Alineación a 90º y Radio 50m:**



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3.1.6. Gradients and grade changes

The below values are to be confirmed by the region project by project.

	Longitudinal Gradients (%)				Transversal Gradients (%)	
	Maximum		Minimums		Maximum	Minimum
	Straight section	Curved section	Straight section	Curved section	Straight/ curved section	
Wind farm access road and internal wind farm road	>10 and ≤13 without concreting if gradient < 200 m. (1) >10 and ≤13 improved concreting or paving if gradient > 200 m. (1) >13 and ≤15 improved concreting or paving + 6x6 tractor unit >15 need for towing study	Up to 7 without concreting (1) >7 and ≤10 improved concreting or paving (1) >10 need for towing study	0.50	0.50	2	0.20
Access and internal roads reverse driving	≤ 3 up to a max. of 1000 m without concreting. >3 and ≤5 max. 1000m improved concreting or paving	<2 up to max. 500 m without concreting. ≥2 and ≤3 max. 500 m improved concreting or paving	0.50	0.50	2	0.20

(1) SGRE standard values are ≤13 % for longitudinal gradients and <10 % for curved sections.
(2) Improved paving: Roadbed with friction coefficient of at least 0.35

Table 6. Gradients and grade changes

For gradients near 10% without concreting, 6 x 4 tractor units or four-wheel drive truck will be required.

In the specified cases in which road paving must be improved, the solution to be used and the envisaged friction coefficient must be submitted so that transport can be executed.

In the specified cases in which road paving must be improved, the technical characteristics of the solution to be used must be submitted, as well as the friction coefficient for the roadway layer envisaged for said solution, thereby ensuring that all components are transported correctly.

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If the longitudinal gradient is >13% and ≤15%, improved concreting or paving will be required, and a 6 x 6 tractor unit used. This means that the slope will also have to be reviewed since it is not within SGRE standards.

In the extreme case that a longitudinal gradient in a straight section is >15% and/or is >10% in a curved section, a towing study must be conducted in addition to improving the road paving along the affected section. This study must be conducted by the logistics company in charge of supplying the wind farm with the wind turbine components.

Regarding to guarantee the proper transitions between gradient changes, the minimum straight-line total length of the convoy must be kept in mind. According to the complexity of the wind farm project, these points must be analyzed and discussed to find the proper solution.

Ltot: Total length of the convoy.

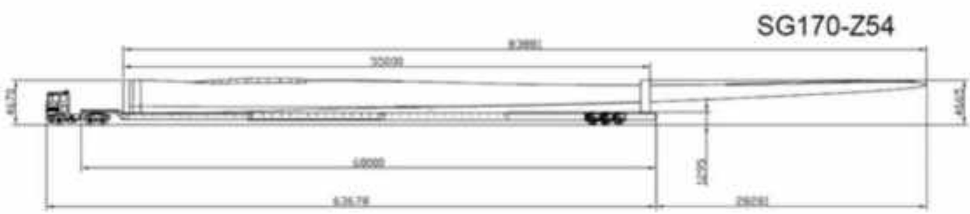
Figure 3. Transitions between gradient changes

For the calculation of the more restrictive KV that appears in this document, estimated generic vehicles have been considered. This does not mean that there are not others that improve or even worsen the KV figure. It is advisable to carry out a specific study in each region of the SGRE, with the vehicles planned to be used in local projects.

The KV value considered in the wind farm design for this WTG model shall be, **as a minimum:**

Transport	Z54	Dolly
Kv Value	690	610

With the information we have now, **the most restrictive transport would be the SG170 blade on Z54 transport.** Bearing in mind that all the axles of the platform would be in contact with the ground. Considering that all the axles of the platform would be in contact with the ground and a rear overhang of 15,64m. Which of course will be different considering the restrictions of each country. The overhang may differ according to the restrictions of each country, which should be considered.



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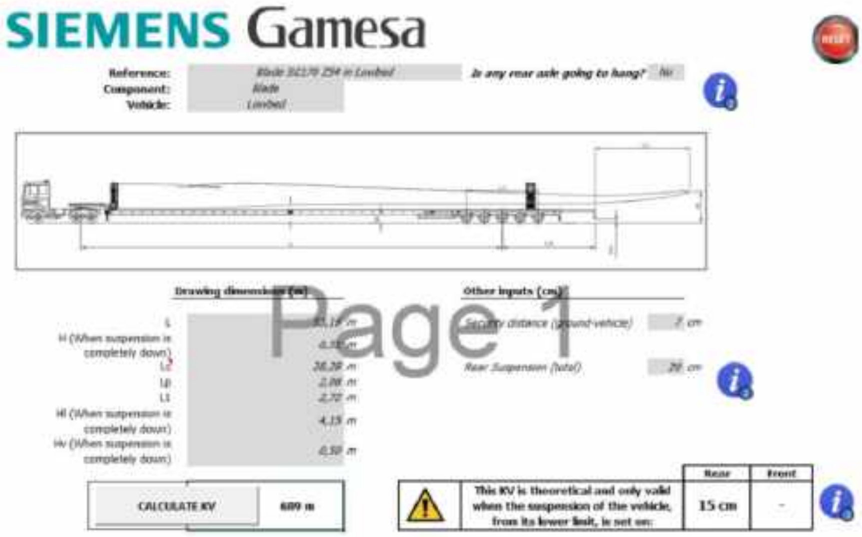

Figure 4. The most restrictive transport and its respective KV

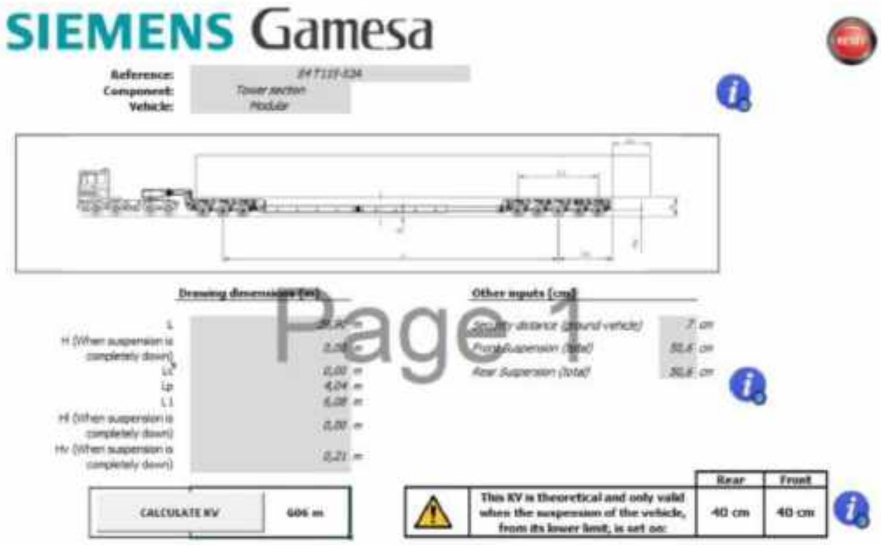

Figure 5. The most restrictive transport in dolly and its respective KV

The value above is for reference only, project value to be confirmed by the region. Depending on the complexity of the terrain, the KV value that minimizes LCoE (levelized cost of energy) might be higher (flat wind farm) or lower (mountainous wind farm). Prior to signing the contract, a specific study shall be done in order to define the proper KV for the wind farm, considering development constraints in force and locally available transports in order to adapt logistics means accordingly.

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The specific study could include nonstandard solutions and extra resources for each solution.

The roads must be smooth, removing, as far as possible, any protrusions such as stones, rocks, etc., which could damage the nacelle hardstand or the tower sections and hinder transportation.

3.1.7. Passing areas and turning points

Passing areas will be created at intervals of approximately 5 km, attempting to take advantage of the areas where there are less actions to be performed if possible and they must have an extra width of 5 m with a minimum length equal to the total length of the convoy (Ltot) with a greater length. It is important to consider the entry and exit areas to facility access to the area. The waiting areas must be clear of any obstacle, levelled, compacted and drained. QHSE will determine the number of rest areas that must be created.

The turning points must be defined according with the maximum allowed reverse maneuver as described at the item ***3.1.5 Gradients and grade changes.***

Where dead end roads are constructed or where loaded transports must turn around prior to delivery to the Installation Area, turning Areas are required to avoid long reverse driving. For each wind farm project, these points must be analyzed to find the proper solution.

(Note) Truck length* - The turning area will be different considering two situations: Loaded truck and empty truck. The additional area must be considered around the turning point - cleared of obstacles and levelled to allow oversail/ overhang during transportation. The turning point could be adapted regarding the orography and/or complexity of the windfarm terrain, the new geometry must be approved by SGRE in order to comply with the transport requirements.

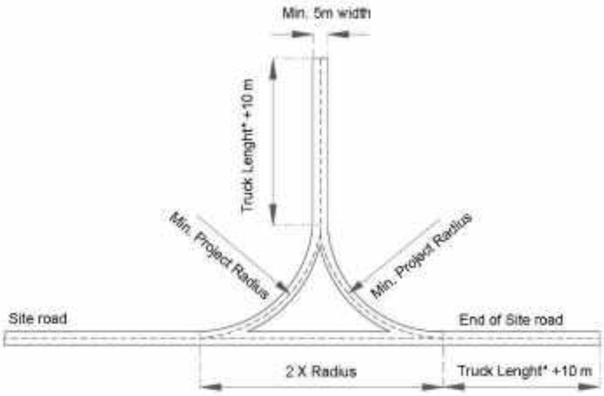

Figure 5. Turning point geometry suggestion

These can be adjusted on project specific.

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3.1.8. Drainage

The surface drainage system must be of a size to collect any rainwater from the roadway layer as well as any water collected from small flows of runoff water intercepted by the road or even, where applicable, to provide continuity for any larger natural watercourses also intercepted. The calculation will be considered for a return period of 25 years for transverse drainage and 10 years for longitudinal drainage works.

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3.2. Hardstands

The hardstands will include a crane work area and areas defined as storage areas. The main components will be stored on the storage area, and they will be hoisted by the cranes from the hardstand – crane work area, as a standard concept. Regarding the high-power and communications networks avoid placing them across the hardstand. If this cannot be avoided, then the network must be pipelined, and the pipes covered with concrete.

3.2.1. Hardstand design

The design of the hardstand section must be done based on the geotechnical report and the load transferred by the crane support legs, also it must be considered the use of crane mats if any, under the crane support.

The structural verifications that must be performed and the criteria to be used is as follows:

- For the bearing capacity analysis, Meyerhof and Hanna (1978) methodology will be used.
- The safety factor for the verification of the bearing capacity will be 2, for both long term and short term.
- For the analytical calculation of the settlements, the Steinbrenner methodology will be used.
- The maximum differential settlement under the crane support leg will be 40 mm.

When it comes to unfavourable geotechnical conditions, in addition to the verifications carried out with analytical methodologies, described above, it will be necessary to develop a finite element model (FEM) to compare and contrast the results obtained with analytical methodologies.

The design of the hardstand and the geotechnical report will be provided to Siemens Gamesa together with the quality control of the hardstand, during the handover of the civil works and before starting with the erection process.

3.2.2. Bearing capacity

	Crane work area	Component storage area	Boom assembly area
SGRE standard	2.5	2	2
Without crane mats	3 (T100) 3 (T110.5) 3 (T115m) 4 (T135m) 5 (T145m) 5 (T150m) 5 (T155m) 5 (T165m)	2	2

Table 7. Load -bearing capacity (kg/cm2)

The composition of the crane work area must have a good subgrade, Ev2=60MPa or above. Transmitted loads must be 2.5kg/cm2 (approx. 0.2MPa). A surface of 30 m² must be laid, 6 crane mats (5 m x 1 m) per crane leg or crane chain.

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If opting not to use crane mats, the necessary bearing capacity will be 3 kg/cm² for T100m, T110.5m and T115m, 4 kg/cm² for T135m and 5 kg/cm² for T145m, T150m, T155m and T165m tower models. The possible supply of crane mats is not included in the scope of SGRE, whereby if opting to use crane mats, the cost thereof shall be incurred by the Contracting Party.

3.2.3. Hardstand composition and structure

In the hardstand, the upper level of the subgrade must be above the highest foreseeable level of the water table. Where expansive material (expansive clay, etc.) or loose soil conditions are indicated in the geotechnical report, the use of geosynthetics is strongly recommended (at least with the soil reinforcement and separation functions).

The fill material will be compacted on the hardstands and in the storage areas in layers to a maximum thickness of 30 cm to ensure the effectiveness of the machinery along the entire section. The compaction level will be such that the dry density after compaction is 95% MP or higher. The elasticity module of the subgrade must be measured based on the compressibility module of the second cycle of the load plate test as per DIN 18134 (or in its absence, NLT-357), 600 o 762mm plate will be used for this test, the acceptance criteria will be indicated in the hardstands section design.

Regarding the finished hardstand, the compaction level will be such that the dry density after compaction is 98% MP or higher. The elasticity module of the finished hardstand surface must be measured based on the compressibility module of the second cycle of the load plate test as per DIN 18134 (or in its absence, NLT-357), and the result must never be less than Ev2>80 MPa. Likewise, the relation between the first and second load cycle must be less than 3.

In case there is a doubt about the hardstand capacity, it will be necessary to execute at least one borehole, in the centre of the crane area, with core recovery and a depth of 8m. During the execution of the borehole, the following works should be conducted:

- SPT: from the surface where a test must be performed every meter.
- Extracting non-disturbed samples, plus laboratory test (triaxial tests or direct shear tests).
- Determining the ground water level depth, if encountered.
- Collect sampling for laboratory characterization of all the encountered materials.

The storage areas that are at the same level and position of the crane work area (for towers and nacelle), the requirements for the subgrade and finished layer are the same as above-mentioned. For the blade storage areas, the compaction level of the subgrade will be such that the dry density after compaction is 95% MP or higher. In case of need of granular layer, the compaction level will be such that the dry density after compaction is 98% MP or higher.

In case the subgrade of the storage areas is good enough to withstand the loads, no layer of granular material will be needed, but this must be justified accordingly in the design.

Tests must be carried out on the material used for the subgrade and for the roadbed, in order to control the compaction of the different layers and ensure that the civil works are correctly executed. The quality control and the requirements for the civil works design is defined according to the ***5.3 Quality tests and requirements for civil works plan projects.***

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Before the arrival of the transport vehicles and crane, the hardstand must be accepted by SGRE for the works to commence.

3.2.4. Hardstand gradients

Crane Type	Hardstand gradients (%)			
	Crane work area		Component storage area	
	Maximum	Minimum	Maximum	Minimum
NTC or Mobile cranes	3	0.2	1.5	0.2
WTC	0.5			

Table 8. Hardstand gradients (%)

The minimum slope in the crane work area as well as the storage area is 0.2%, for the drainage of surface water; concave areas that may result in the formation of pools and the consequential drift of material under heavy loads cannot be accepted. Furthermore, take care that the hardstand or storage area surface must not drain off onto its access road.

3.2.5. Hardstand dimensions

Hardstand layout considers standard SGRE assembly strategy 4.

Foundation diameter subject to change. In case of using special foundation solution (uplifted, braced foundation, etc.), the hardstand dimension must be evaluated and approved by specific study.

(Note) – Following hardstand layouts covering tailing crane offloading and self-offloading transports

Use of clamp system doesn't require cranes for off-loading but additional space for manoeuvring of trailers to release the tower sections is needed. The system is not available for all regions and must confirmed by SGRE before building the windfarm. Bear in mind, once chose the hardstands without to consult or to require a confirmation from SGRE, the decision is responsibility of the civil designer. The different concept reflects an impact in hardstand layout, assembly phase and costs. Unusual situations must be evaluated and approved project specific.

Position of blade fingers is depending on location of transport equipment (TEQ) on blade -> Use of TEQ concept and/or positioning on blade might be different per region. Final location of blade fingers must be evaluated and approved project specific.

Area	Description
q1	Hardstand for main crane
q2	Hardstand for assistant crane
q3	Storage area for containers and miscellaneous items
q4	Blade storage area (including the blade fingers position)
q5	Storage area for components
q6	Hardstand for boom assembly
q7	Free obstacles area for rotation superlift ballast or suspended ballast of main crane

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Table 9. Installation area codes and description

HARDSTAND LEGEND

- Site Road
- q1 Hardstand for Main Crane
- q2 Hardstand for Assist Crane
- q3 Storage/Assembly Area
- q4 Trestle area for blades
- q5 Storage area for components
- q6 Hardstand for Boom Assembly
- q7 Hardstand for Superlift ballast

The hardstand drawings can be found in annexes, section *5.4 hardstand dimensions*.

In all hardstands, 2 additional areas of 19 m x 12 m and 16 m x 12 m will be required for storing the containers and miscellaneous items. These areas must be close to the hardstand. They can be positioned alongside the foundation providing they remain accessible for removing material by boom truck or telescopic forklift.

The blade storage area will be formed by two different zones in q4. The first zone are two reinforced and levelled "fingers" where blades are supported. The second zone is the surrounding area of blade fingers in q4. As a standard, the entire area of q4 should be levelled with road and/or hardstand next to it and cleaned from obstacles (working area).

The top part of the blade fingers must be at the same level as the surrounding hardstand.

If the blade fingers area is higher or lower than the adjoining road, this must be approved by Siemens Gamesa as it will have an impact on the delivery of the blades.

In addition, a work area must be secured at least 1m between and around to the blades.

The dimensions of the vehicle and crane work areas as well as the storage areas inevitably determine the configurations of the equipment used for assembly. For this reason, this section also defines some of the standard or normal conditions used to define the basic prices as well as relevant exceptional cases.

The recommendable distance from the centre of the ring to the start of the useable surface of the hardstand will be 5 m. (Each specific case may be studied).

The concrete foundation pedestal and hardstand must have the same level where possible.

It can be lower with prior approval from SGRE.

If design requirements call for the foundation pedestal level to differ from the ground surface potentially the level of standard hardstand layout will differ from foundation pedestal, too. In case of a project specific evaluation together with SGRE is required (e.g adaptation of hardstand level to foundation pedestal level or change of crane set up and updated of size of the hardstand).

(Note: If opting for an elevated foundation due to design reasons, its height in relation to the hardstand should be considered as tower height.)

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Intermediate hardstand adjacent to the road, but at a different level, must have a separate hardstand entrance and exit. Otherwise, it must be considered end-of-road hardstand.

For end-of-road hardstands, the foundation should be at the end of the hardstand, avoiding having the foundation at the entrance of the hardstand as much as possible.

The hardstand and road must be at the same level to be able to operate support cranes located partially on hardstand and road.

3.2.6. Requirements for tower assembly with T-flange configuration between section 1 and 2

A compacted area around the tower (on top of foundation) needs to be prepared in advance of start of 1st tower section installation. This is needed to enable tower access from all sides for installation of T-flange bolt joints with e.g., cherry picker (man basket).

The compacted area needs to have a minimum width of 10m for operation of cherry picker.

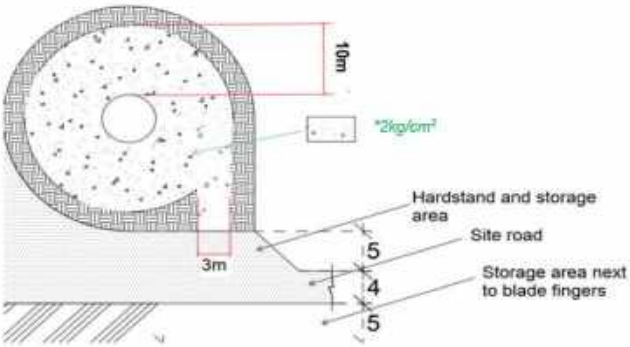

Figure 6. Example of hardstand layout and access road/ramp

Note:

If an elevated foundation is applicable a road/ramp for access to compacted must be created, too. Maximum gradient of 15% must be considered.

*The bearing capacity for the backfilling is a recommendation for complying with the CNS requirements. This number needs to also fulfil the foundation design requirements.

3.2.7. Requirements for assembly the main crane

If there are several branches far away from one another, an area must be prepared for assembling and disassembling the boom of the main crane at the beginning and end of each wind farm branch or on each hardstand depending on the crane model to be used.

The boom assembly configuration and area may vary according to the crane models to be used.

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If there are very steep gradients, power lines, etc., more assembly and disassembly areas for the boom of the main crane may be needed on each hardstand.

This area must have a minimum length in a straight line equal to:

- 100m tower: Tower height + 19m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 110.5m tower: Tower height + 19m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 115m tower: Tower height + 19m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 135m tower: Tower height + 15m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 145m tower: Tower height + 19m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 150m tower: Tower height + 23m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 155m tower: Tower height + 21m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)
- 165m tower: Tower height + 12m and a minimum width of 3m, with two 6m x 6m supporting areas (depending on the crane, the location of the crane and the boom configuration)

		T100 m	T110.5 m	T115 m	T135 m	T145 m	T150 m	T155 m	T165 m	T165 m MB
Mobile/ Crawler cranes	Wheeler Crane	Area for assembly and disassembly on each hardstand and along site road								
	NTC									
	WTC	Assembly area at the beginning and end of the Wind Farm or each branch								
Dimensions	In a straight line	119m	130m	134m	150m	164m	173m	176m	177m	177m
	Wide	3m	3m	3m	3m	3m	3m	3m	3m	3m

Table 10. Requirements for assembly the main crane

There must be areas without vegetation, flat and compacted with a surface area of 10 m x 12 m + 7m x 12m / 2, every 30 m along the boom for assembly for the tailing cranes operation:

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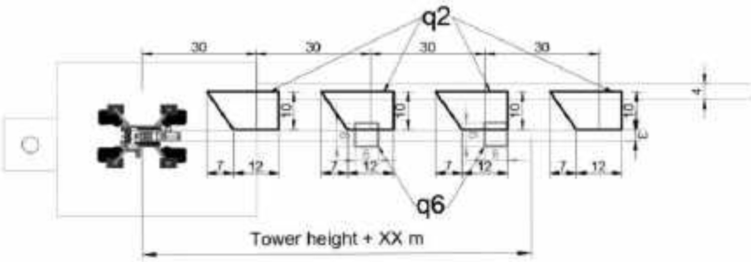

Figure 7. Distribution areas for main crane boom assembly

This area must also be as horizontal as possible, and any gradient should preferably be upward (in the direction in which the boom assembly advances). Were it downward, the boom assembly conditions would be more complex, increasing the crane means required for the assembly process. This would not be a SGRE standard and a specific study would need to be done.

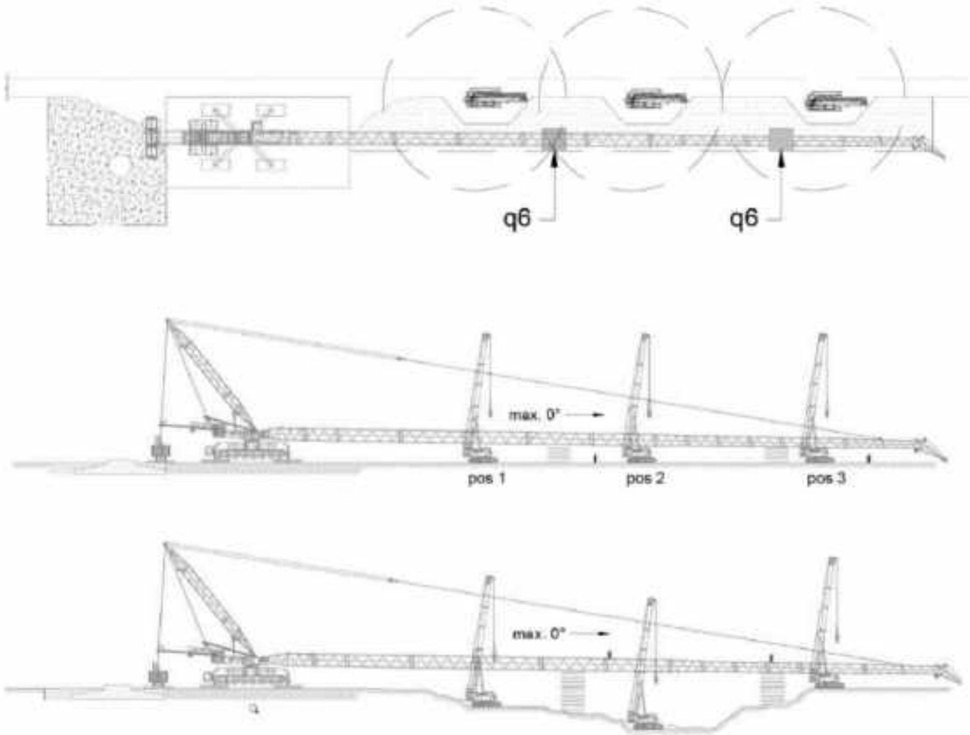

Figure 8. Boom assembly on flat and hilly terrain

Furthermore, the subgrade for assembly and disassembly of the boom, including the pre-installation crane positioning areas, must have a supporting capacity over the entire area at work level of 2 kg/cm² (approx. 0.2 MPa).

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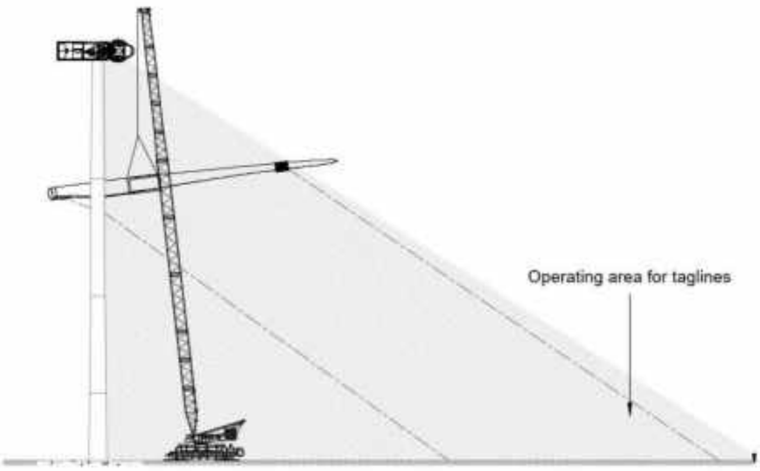
The areas for mounting and dismounting the main crane should be next to a hardstand but not overlap the hardstand area. Furthermore, they will be laid out as parallel as possible to the road reaching the hardstand, but without overlapping it, **in order to avoid invading the outgoing WF road in case of.**

3.2.8. Areas for Tag Lines

Rotor Assembly and Single blade Installation Methods (see Figure 9) require special attention for ensuring a cleared area for the safe use of tag lines.

The Employer shall ensure that the areas around the hardstand, rotor assembly area, and operating area for tag lines are prepared to allow rotor assembly and installation, or single blade installation to be completed safely. An example of the area required is shown in Figure 9. This area shall be prepared as a Working Area (free from trees, obstacles and trip hazards and prepared as to allow persons to move freely and safely). Once the Employer's civil design is finalised, the Contractor shall work with the Employer to further define and optimize these areas in order to minimise the felling and ground preparation works to be carried out by the Employer. Prior to turbine erection, the Employer and Contractor shall together survey the area to be used for tag lines and identify any safety hazards (e.g. holes, level changes, marsh etc.). The Employer and Contractor will mutually agree appropriate mitigations measures, which will be carried out by the Employer, to ensure Safe Working Access.

The drawings below are indicative only and can be furthered refined during the site visit. This is relevant for rotor assembly only.



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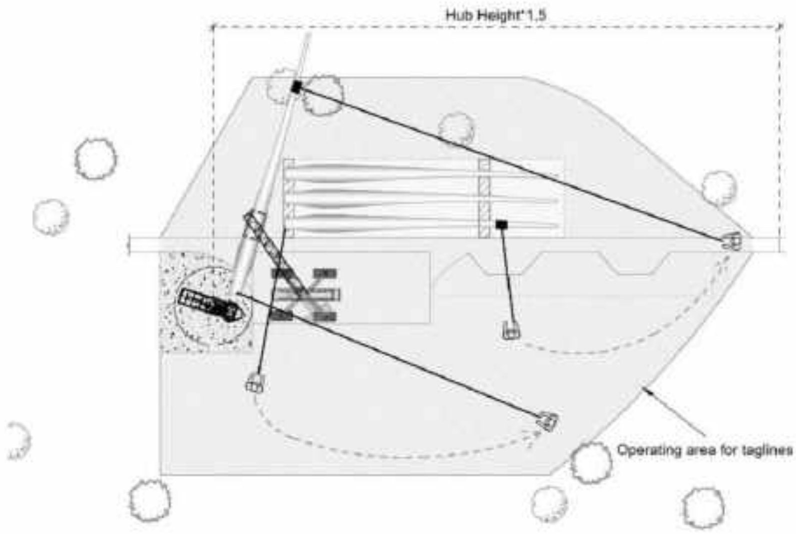

Figure 9. Indicative drawing of area requirements for the use of tag lines with single blade installation method

3.3. Minimum Requirements for temporary site compounds of wind farms

The objective of this Internal Note is to specify the minimum requirements for the temporary site hardstands including the area of the site office sheds/containers, the parking area for light vehicles and the storage area for minor materials. Normally all these areas form a single space usually called "**site compound**", which is divided into the pertinent specific areas.

The site compound is needed for the construction of a wind farm, and each area must be in good conditions for each specific purpose. Therefore, these temporary areas must be built in accordance with specific requirements.

The location of the site compound must be carefully studied, avoiding areas susceptible to suffering flood events and avoiding areas with critical natural slopes or large embankments. Preferred locations are flat areas with easy access by car or truck.

The design of this site compound must consider a slope between 1% and 3%, for a proper drainage of the rainwater in accordance with the site specific conditions. If necessary, temporary drain ditches or culverts should also be considered to collect and divert the rainwater to the appropriate discharge points.

The construction of these temporary areas will require the following activities:

1- The area must be cleared to eliminate the topsoil, trees, stumps, weeds, etc. The topsoil can be stockpiled in small piles in the vicinity of the site compound for later use in landscape restoration if required.
2- Embankments: If relevant embankments are necessary to build the hardstand, at least the following requirements are recommended:

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- Before the construction of the embankment, the natural subgrade must be compacted until reaching 95% of the maximum dry density from the Modified Proctor test (M.P.).
- Embankment construction must be carried out by placing fill material in max. 30cm thick layers and compacting this fill material until reaching 95% of its maximum dry density from the M.P.
- It is recommended using a fill material with a CBR ≥4% at 95% M.P, free of organic matter, LL<50, non-collapsible, free swelling <3%.

3- Excavations: If excavation is necessary to build the hardstand, the exposed natural subgrade must be compacted until reaching 95% of the maximum dry density from M.P.

4- Pavement: The pavement details will depend on the use of each area but, as a general approach, it is recommended a granular material with a fine content ≤ 20%, a CBR≥ 40% at 98% M.P. and a maximum grain size of 32mm, when possible. This material must also be correctly compacted in max. 30cm thick layers until reaching at least 98% of the maximum dry density from M.P. ("=well compacted granular material").

Paved areas and the thickness of the pavement will depend on the site soil conditions and the associated evaluation will adequately consider the detailed geotechnical information. There may even be the case that the use of geotextiles could be necessary.

Recommended thickness of the pavement in each area is indicated below. The thicknesses must be considered as a minimum and obviously it can also be increased if the site soil conditions are not good enough.

- Temporary office area: it is recommended applying 10cm of well compacted granular material.
- Parking area for light vehicles: it is recommended applying 15cm of well compacted granular material.
- Storage area for minor materials and access road: trucks are going to use these areas. Therefore, the thickness of pavement will depend on the quality of the natural soil (subsoil):
  - Poor subsoil conditions (CBR<2% at 95% P.M.): it is recommended applying at least 30cm of well compacted granular material.
  - Fair subsoil conditions (2%<CBR<7% at 95% P.M.): it is recommended applying at least 20cm of well compacted granular material.
  - Good subsoil conditions (CBR>7% at 95% P.M.): it is recommended applying at least 15cm of well compacted granular material.
  - If rock or rocky soils are encountered, it would be enough to apply 10cm of well compacted granular material in all the areas to build a uniform, plain and sufficiently bearing hardstand.

Above recommendations must be understood as a general guide or a first approach to the structural design of the temporary hardstands.

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In any case, it is always necessary to maintain adequately the pavements. If necessary, additional granular material must be placed and correctly compacted during the use of these temporary areas.

If these temporary areas are going to be used for storing of the turbine components and/or very heavy items that require the use of cranes, they will be considered as a usual WTG hardstand and analysed and designed in accordance with the Site Specific Requirements (SSR) of each project.

3.4. Safety distance from power lines

The Orders and Regulations in force in each country must be considered where high and low-voltage lines pass over the internal wind farm roads or wind farm access roads.

Distance limits for working areas are included as a reference.

U_n	D_{PEL-1}	D_{PEL-2}	D_{PROX-1}	D_{PROX-2}
≤ 1	50	50	70	300
3	62	52	112	300
6	62	53	112	300
10	65	55	115	300
15	66	57	116	300
20	72	60	122	300
30	82	66	132	300
45	98	73	148	300
66	120	85	170	300
110	160	100	210	500
132	180	110	330	500
220	260	160	410	500
380	390	250	540	700

Table 11. Safety distance from power lines to work areas

(Note) The distances for intermediate voltage values will be calculated using linear interpolation.

Where:

- U_n - Rated voltage of the installation (kW).
- D_{PEL-1} - Distance to the outer limit of the danger area whenever there is a risk of voltage stressing due to lightning (cm).
- D_{PEL-2} - Distance to the outer limit of the danger area when there is no risk of overvoltage due to lightning (cm).
- D_{PROX-1} - Distance to the outer limit of the danger area whenever it is possible to mark out the work area accurately and control that this is not exceeded during the carrying-out of the work (cm).

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- D_{PROX-2} - Distance to the outer limit of the danger area whenever it is not possible to mark out the work area accurately and control that this is not exceeded during the carrying-out of the work (cm).

4. Additional documentation

This document is of a general character and it is necessary to include another document (e.g. External Note) specifying any additional requirements or revision/confirmation of the parameters of this document, in addition to:

- Number of WTGs.
- Turbine type. If there is more than one type, this should be specified position by position.
- Installation strategy and storage conditions. If there is more than one type, this should be specified position by position.
- Main, pre-assembly and assist crane proposed.
- Road width in the access road and between positions.
- Semi – mounted crane movement road requirements and affected road sections.
- Auxiliary means for transports as pull units. This should also include the road sections in which this auxiliary means are needed.
- Additional hardstands, in case needed (temporary storage).
- Confirmation of the widening curves table.
- Revision/confirmation of the parameters, e.g. KV, longitudinal gradients…
- Specification of dimension and other requirements of site facilities.
- Any other project specific requirements.

HSE, project by project, must also define their requirements. I.e. safety distances to the edge of the hardstands, in case there is a high difference in level.

To define the above information, receiving the Layout of the WF and other information is required.

This data will give a visualization of each wind turbine of the wind farm and it will convey any needed extra methods or measures in addition to the SGRE standards.

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5. Annexes

5.1. Transport requirements

(Note): The data represented below is the result of the of the study was obtained from the modelling, showing the following widening according to the cargo and bed. The values are a reference considering the transport from the item ***3.1.5 Gradients and grade changes.*** For each windfarm and region, please bear in mind some changes could be possible. Concerning this, a new study must be done by Logistics department according with the transport available per region/project to avoid some nonconformities.

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VEHICLE: SG170, LEFT TURN

Radius (m)	10º			20º			30º			40º			50º			60º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	5	1,5	1,5	6	1,5	4,5	6	1,5	8	6	4	11	7	5,5	15	7	7	19
10	5	1,5	1,5	6	1,5	4,5	6	1,5	8	6	3,5	11	7	5,5	14,5	7	7	18
15	5	1,5	1,5	6	1,5	4,5	6	1,5	7,5	6	3,5	10,5	7	5	[illegible]	7	6,5	17,5
20	5	1,5	1,5	6	1,5	4,5	6	1,5	7,5	6	3,5	10,5	[illegible]	[illegible]	[illegible]	7	6	16,5
25	5	1,5	1	6	1,5	4,5	6	1,5	7,5	6	3	10	[illegible]	4,5	[illegible]	7	6	16
30	5	1,5	1	5	1,5	4,5	6	1,5	7	6	3	10	[illegible]	[illegible]	12,5	7	5,5	15
35	5	1,5	1	5	1,5	4	6	1,5	7	[illegible]	3	[illegible]	6	4	12	7	5,5	14,5
40	5	1,5	1	5	1,5	4	6	1,5	[illegible]	[illegible]	[illegible]	9	6	4	11,5	7	5	13,5
45	5	1,5	1	5	1,5	4	6	1,5	6	[illegible]	[illegible]	9	6	3,5	11	7	4,5	13
50	5	1,5	1	5	1,5	4	[illegible]	[illegible]	6	[illegible]	2,5	8,5	6	3,5	10,5	6	4,5	12
55	5	1,5	1	5	1,5	[illegible]	[illegible]	[illegible]	[illegible]	6	2,5	8	6	3,5	10	6	4	11,5
60	5	1,5	1	[illegible]	[illegible]	[illegible]	6	1,5	6	6	2	8	6	3	9,5	6	4	10,5
65	5	1,5	[illegible]	[illegible]	[illegible]	3,5	6	1,5	6	6	2	7,5	6	3	9	6	3,5	9,5
70	5	1,5	[illegible]	[illegible]	[illegible]	3,5	6	1,5	5,5	6	1,5	7,5	6	2,5	8,5	6	3,5	9
75	5	1,5	[illegible]	5	1,5	3,5	6	1,5	5,5	6	1,5	7	6	2,5	8	6	3	8
80	5	1,5	1	5	1,5	3,5	6	1,5	5,5	6	1,5	6,5	6	2	7,5	6	2,5	7,5
85	5	1,5	1	5	1,5	3,5	6	1,5	5	6	1,5	6,5	6	2	7	6	2	7
90	5	1,5	1	5	1,5	3,5	6	1,5	5	6	1,5	6	6	1,5	6,5	6	1,5	6,5

Radius (m)	70º			80º			90º			100º			110º			120º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	8	8	23,5	11	8	28	15	8	34	6	0	0	6	0	0	6	0	0
10	8	8	22	10	8	26,5	13	8	31,5	18	8	37,5	6	0	0	6	0	0
15	8	8	21	9	8	25	12	8	29,5	16	8	35	6	0	0	6	0	0
20	8	7,5	20	8	8	23,5	10	8	27,5	14	8	32	18	[illegible]	[illegible]	6	0	0
25	7	7	19	8	8	22	9	8	25	12	8	29	[illegible]	8	[illegible]	6	0	0
30	7	6,5	17,5	8	7,5	20,5	8	8	23	10	8	26	[illegible]	8	[illegible]	16	8,5	33
35	7	6,5	16,5	7	7	19	8	8	21	8	8	[illegible]	[illegible]	[illegible]	26	12	8,5	28
40	7	6	15,5	7	7	17,5	7	7,5	19	[illegible]	[illegible]	[illegible]	8	8	22	8	8,5	23
45	7	5,5	14,5	7	6	16	7	7	[illegible]	[illegible]	[illegible]	18	7	7,5	18,5	7	7,5	18,5
50	7	5	13,5	7	5,5	14,5	[illegible]	[illegible]	[illegible]	7	[illegible]	15,5	7	6,5	15,5	7	6,5	15,5
55	7	4,5	12,5	7	5	[illegible]	[illegible]	[illegible]	[illegible]	7	5,5	13	7	5,5	13	7	5,5	13
60	6	4,5	11	6	4,5	[illegible]	[illegible]	[illegible]	11,5	6	5	11,5	6	5	11,5	6	5	11,5
65	6	4	10	[illegible]	[illegible]	[illegible]	6	4	10	6	4	10	6	4	10	6	4	10
70	6	3,5	[illegible]	[illegible]	[illegible]	9	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9
75	6	3	[illegible]	[illegible]	[illegible]	8,5	6	3	8,5	6	3	8,5	6	3	8,5	6	3	8,5
80	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5
85	6	2	7	6	2	7	6	2	7	6	2	7	6	2	7	6	2	7
90	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5

Radius (m)	130º			140º			150º			160º			170º			180º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
10	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	[illegible]	0	0
15	6	0	0	6	0	0	6	0	0	6	0	0	6	0	[illegible]	[illegible]	0	0
20	6	0	0	6	0	0	6	0	0	6	0	0	6	[illegible]	[illegible]	[illegible]	0	0
25	6	0	0	6	0	0	6	0	0	6	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0
30	6	0	0	6	0	0	6	0	0	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	0	0
35	15	8,5	31	19	8,5	35	6	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	6	0	0
40	9	8,5	24	11	8,5	25,5	12	8,5	26	[illegible]	8,5	[illegible]	16	8,5	29	18	8,5	31
45	7	7,5	18,5	7	7,5	18,5	8	[illegible]	[illegible]	8	[illegible]	18,5	8	7,5	18,5	8	7,5	18,5
50	7	6,5	15,5	7	6,5	15,5	7	6,5	[illegible]	7	6,5	15,5	7	6,5	15,5	7	6,5	15,5
55	7	5,5	13	7	5,5	[illegible]	7	5,5	13	7	5,5	13	7	5,5	13	7	5,5	13
60	6	5	11,5	[illegible]	5	[illegible]	6	[illegible]	11,5	6	5	11,5	6	5	11,5	6	5	11,5
65	6	4	10	[illegible]	4	[illegible]	[illegible]	4	10	6	4	10	6	4	10	6	4	10
70	6	3,5	9	[illegible]	[illegible]	9	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9
75	6	3	8,5	[illegible]	3	8,5	6	3	8,5	6	3	8,5	6	3	8,5	6	3	8,5
80	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5	6	2,5	7,5
85	6	2	7	6	2	7	6	2	7	6	2	7	6	2	7	6	2	7
90	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5	6	1,5	6,5

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VEHICLE: SG170, RIGHT TURN

Radios (m)	10º			20º			30º			40º			50º			60º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	5	4	2,5	6	6	5,5	6	7,5	8,5	6	9	11,5	7	10	15,5	7	10,5	19
10	5	4	2,5	6	6	5,5	6	7,5	8,5	6	8,5	11,5	7	9,5	15	7	10,5	18
15	5	4	2,5	6	5,5	5	6	7,5	8,5	6	8,5	11	7	[illegible]	14	7	10,5	17,5
20	5	4	2	6	5,5	5	6	7,5	8	6	8,5	11	[illegible]	[illegible]	14	7	10	16,5
25	5	4	2	6	5,5	5	6	7,5	8	6	8,5	10,5	[illegible]	9	[illegible]	7	10	16
30	5	4	2	5	5,5	5	6	7	7,5	6	[illegible]	[illegible]	[illegible]	9	13	7	10	15,5
35	5	4	2	5	5,5	5	6	7	7,5	[illegible]	[illegible]	[illegible]	6	9	12,5	7	9,5	14,5
40	5	4	2	5	5,5	5	6	7	[illegible]	[illegible]	[illegible]	[illegible]	6	9	12	7	9,5	14
45	5	4	2	5	5,5	5	6	7	[illegible]	6	8	9,5	6	8,5	11,5	7	9,5	13,5
50	5	4	2	5	5,5	4,5	[illegible]	[illegible]	[illegible]	[illegible]	8	9	6	8,5	11	6	9	12,5
55	5	4	2	5	[illegible]	4,5	6	[illegible]	7	6	8	9	6	8,5	10,5	6	9	11,5
60	5	4	2	[illegible]	[illegible]	4,5	6	6,5	6,5	6	7,5	8,5	6	8,5	10	6	9	11
65	5	4	[illegible]	5	[illegible]	[illegible]	6	6,5	6,5	6	7,5	8	6	8	9,5	6	8,5	10,5
70	5	4	2	5	[illegible]	[illegible]	6	6,5	6,5	6	7,5	8	6	8	9	6	8,5	9,5
75	5	4	[illegible]	[illegible]	5,5	4,5	6	6,5	6	6	7	7,5	6	7,5	8,5	6	8	9
80	5	4	[illegible]	5	5,5	4,5	5	6,5	6	5	7	7,5	6	7,5	8	6	7,5	8
85	5	4	2	5	5,5	4	5	6,5	6	5	7	7	6	7,5	7,5	6	7,5	7,5
90	5	4	2	5	5,5	4	5	6,5	5,5	5	7	6,5	6	7	7	6	7	7

Radios (m)	70º			80º			90º			100º			110º			120º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5	8	11	23,5	11	11	28	15	11	34									
10	8	11	22	10	11	26,5	13	11	31,5	18	11	37,5						
15	8	10,5	21	9	11	25	12	11	29,5	16	11	35						
20	8	10,5	20	8	11	23,5	10	11	27,5	14	11	[illegible]	18	[illegible]	37,5			
25	7	10,5	19	8	11	22	9	11	25	12	11	[illegible]	15	[illegible]	33			
30	7	10,5	17,5	8	10,5	20,5	8	11	23	10	[illegible]	[illegible]	[illegible]	11	29	16	11	33
35	7	10	16,5	7	10,5	19	8	[illegible]	[illegible]	[illegible]	[illegible]	23,5	10	11	26	12	11	28
40	7	10	15,5	7	10,5	17,5	7	[illegible]	[illegible]	[illegible]	11	20,5	8	11	22	8	11	23
45	7	9,5	14,5	7	10	16	[illegible]	10,5	[illegible]	[illegible]	10,5	18	7	10,5	18,5	7	10,5	18,5
50	7	9,5	13,5	7	[illegible]	14,5	[illegible]	[illegible]	[illegible]	7	10	15,5	7	10	15,5	7	10	15,5
55	7	9,5	12,5	[illegible]	9,5	13,5	[illegible]	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5
60	6	9	[illegible]	6	[illegible]	12	[illegible]	9	12	6	9	12	6	9	12	6	9	12
65	6	8,5	10,5	6	[illegible]	10,5	6	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5
70	6	8,5	[illegible]	[illegible]	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5
75	6	8	9	6	8	9	6	8	9	6	8	9	6	8	9	6	8	9
80	6	7,5	8,5	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5
85	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5
90	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7

Radios (m)	130º			140º			150º			160º			170º			180º		
	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai	A	Sae	Sai
5																		
10																		
15																		
20																		
25																		
30																		
35	15	11	31	19	11	35												
40	9	11	24	11	11	25,5	[illegible]	[illegible]	[illegible]	[illegible]	11	27	16	11	29	18	11	31
45	7	10,5	18,5	7	10,5	18,5	8	[illegible]	[illegible]	8	10,5	18,5	8	10,5	18,5	8	10,5	18,5
50	7	10	15,5	[illegible]	[illegible]	15,5	7	[illegible]	15,5	7	10	15,5	7	10	15,5	7	10	15,5
55	7	9,5	[illegible]	[illegible]	[illegible]	13,5	[illegible]	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5
60	6	9	12	6	[illegible]	12	6	9	12	6	9	12	6	9	12	6	9,5	12
65	6	9	[illegible]	[illegible]	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5
70	6	8,5	[illegible]	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	9,5	6	8,5	10
75	6	8	9	6	8	9	6	8	9	6	8	9	6	8	9	6	8	9
80	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5	6	8	8,5
85	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5	6	7,5	7,5
90	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7,5	7

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5.2. Quality tests and requirements for civil works projects

The quality control and the requirements for the civil works design is defined according to the ***GD483525-EN, Quality Test Plan for Roads and Hardstands.***

5.3. Legislations

Siemens Gamesa and its affiliates reserve the right to change the above specifications without prior notice.

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5.4. Hardstand dimensions

The sizing of the hardstands is defined by the use of the standard crane LG1750.

5.4.1. T100m tubular steel tower Hardstand with strategy 3

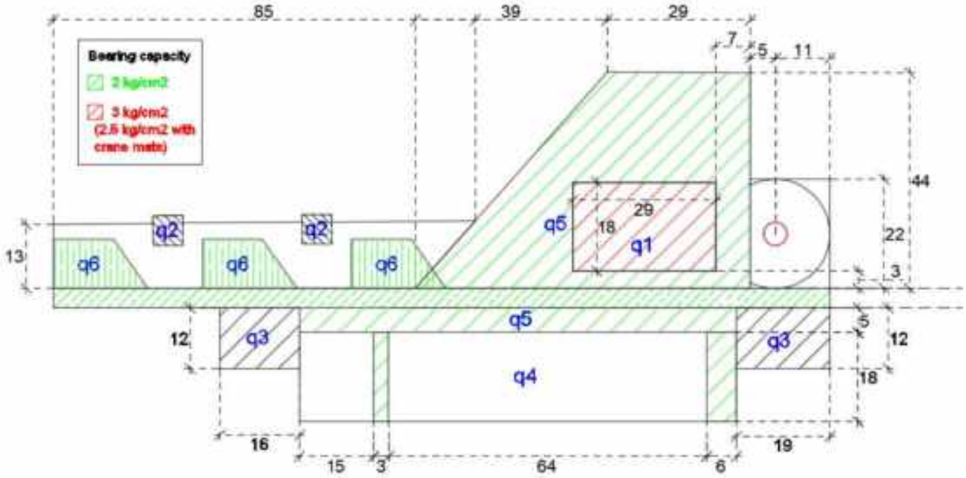
- Tailing crane offloading T100m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 29m x 44m + (39m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 26m x 44m + (35m x 44m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 27. Dimensions of the areas of model T100m with strategy 3 – Tailing crane offloading

*Referred to 3.1.4 Road width

- Total storage – Assembly in 1 phase



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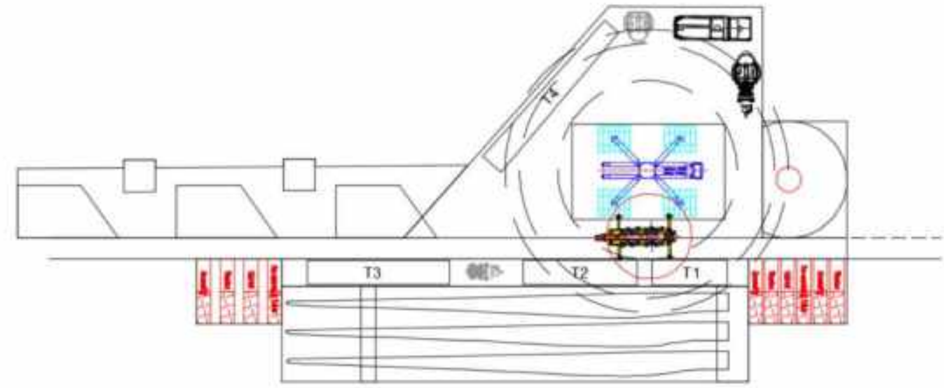
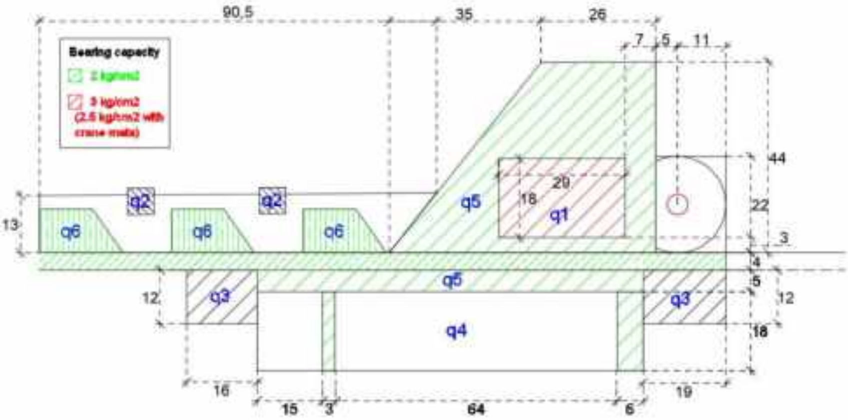


Figure 10 Model T100m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE Standard)



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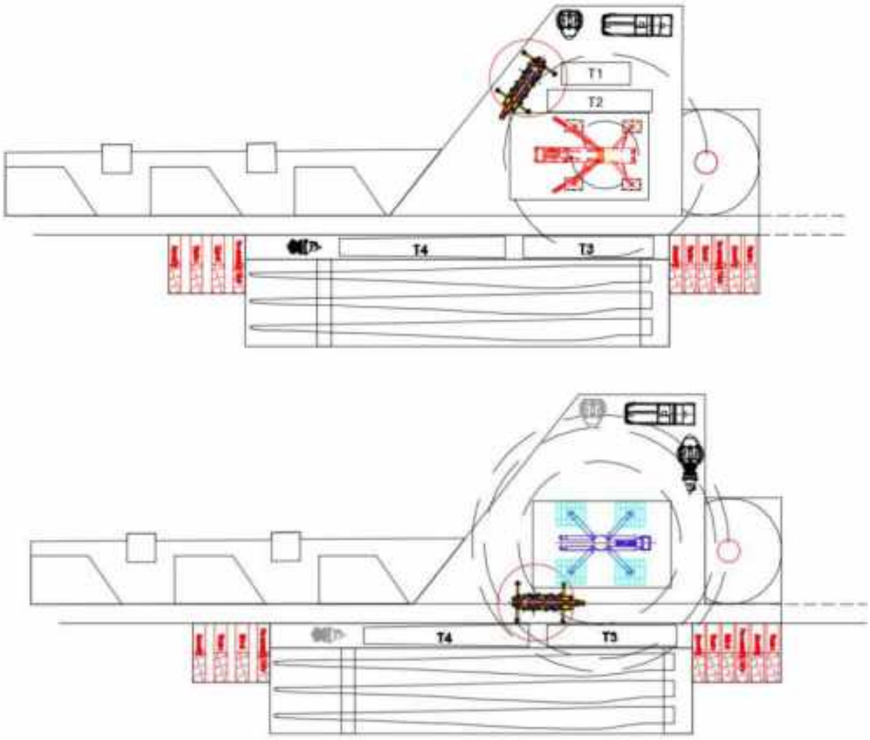

Figure 11 Model T100m – Partial storage assembling with strategy 3 in 2 phases

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5.4.2. T100m tubular steel tower Hardstand with strategy 4

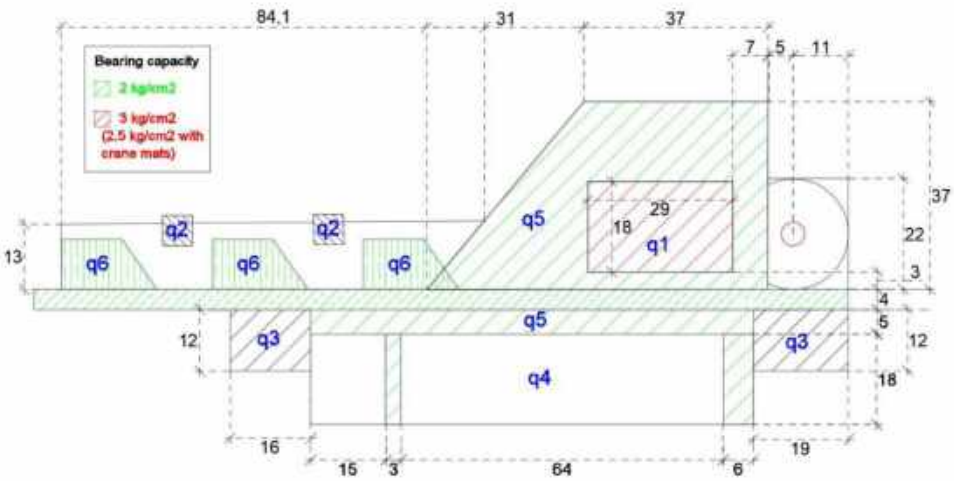
- Tailing crane offloading T100m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 37m x 37m + (31m x 37m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 ....hardstand 3m x 18m + 6m x 18m) q5: 29m x 39m + (32m x 39m)/2 – q1+ 88m x 5m + reinforced road part* q2/q6: dimensions according to the3.2.7. Requirements for assembly the main crane

Table 28.12 Dimensions of the areas of model T100m with strategy 4 – Tailing crane offloading

*Referred to 3.1.4 Road width

- Total storage – Assembly in 1 phase



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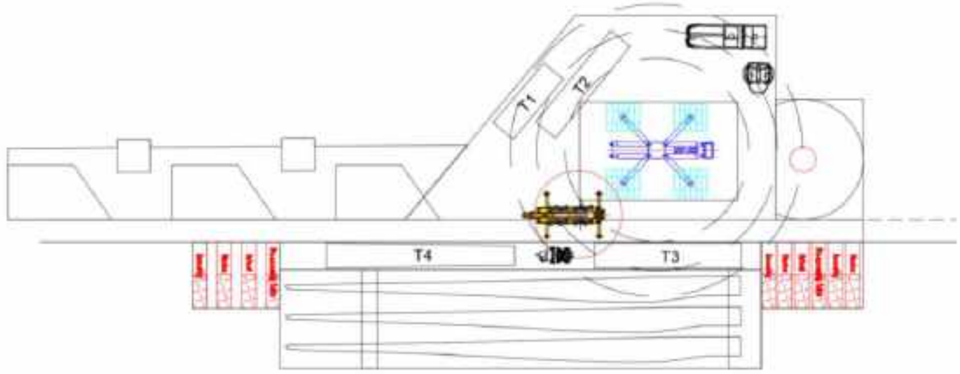
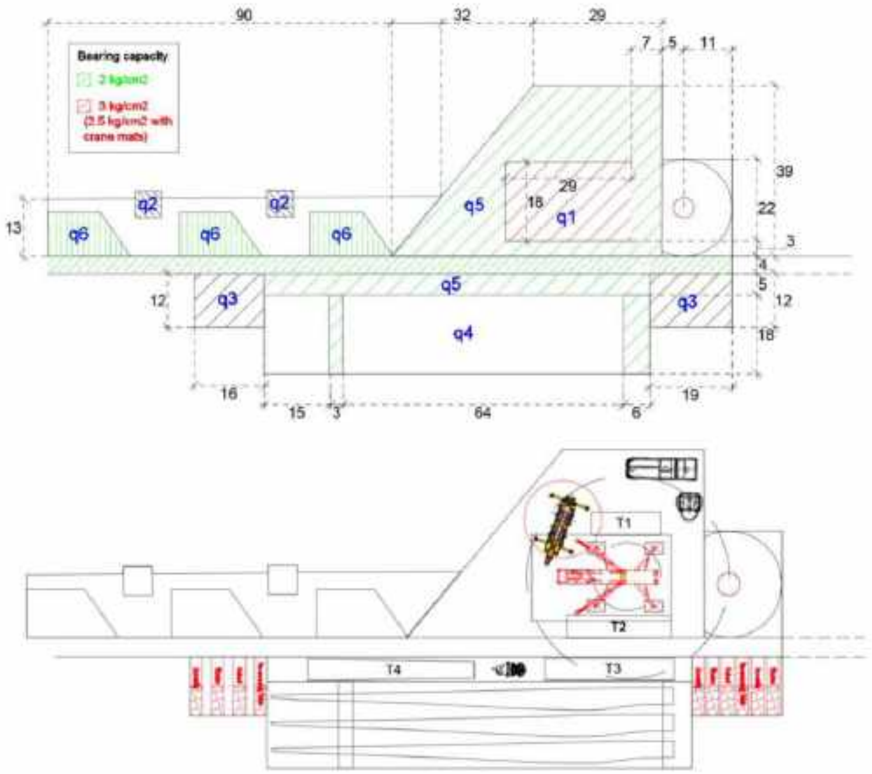


Figure 12 Model T100m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



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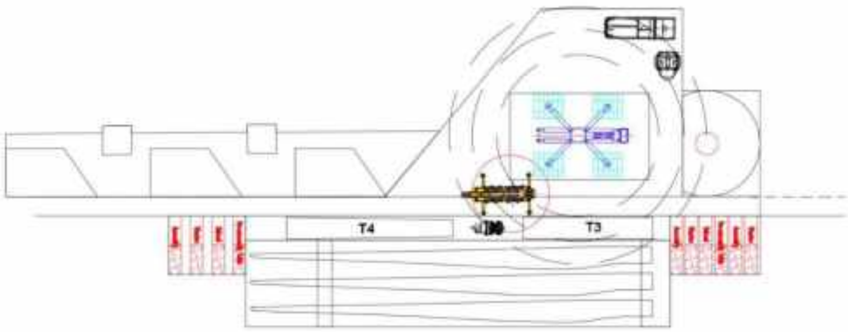

Figure 13 Model T100m – Partial storage assembling with strategy 4 in 2 phases

5.4.3. T110.5m tubular steel tower Hardstand with strategy 3

- Tailing crane offloading 110.5m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 ....hardstand 3m x 18m + 6m x 18m) q5: 33m x 44m + (31m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 ....hardstand 3m x 18m + 6m x 18m) q5: 27m x 44m + (30m x 44m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 29. Dimensions of the areas of model T110.5m with strategy 3 – Tailing crane offloading

*Referred to 3.1.4 Road width

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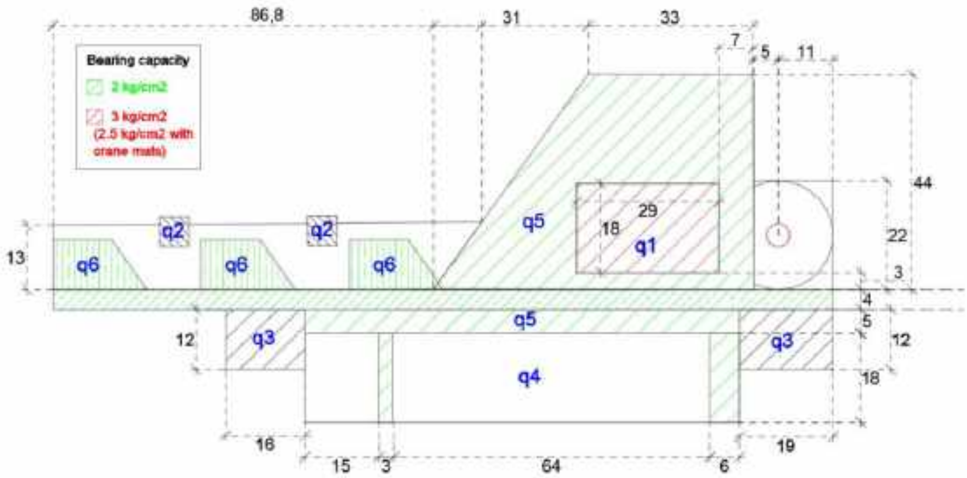
- Total storage – Assembly in 1 phase



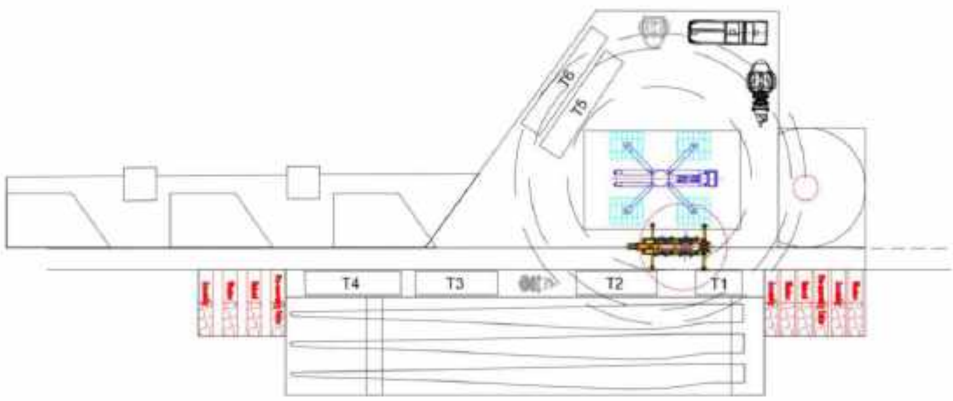


Figure 14 Model T110.5m – Total storage assembling with strategy 3 in 1 phase

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- Partial storage – Assembly in 2 phases (SGRE Standard)

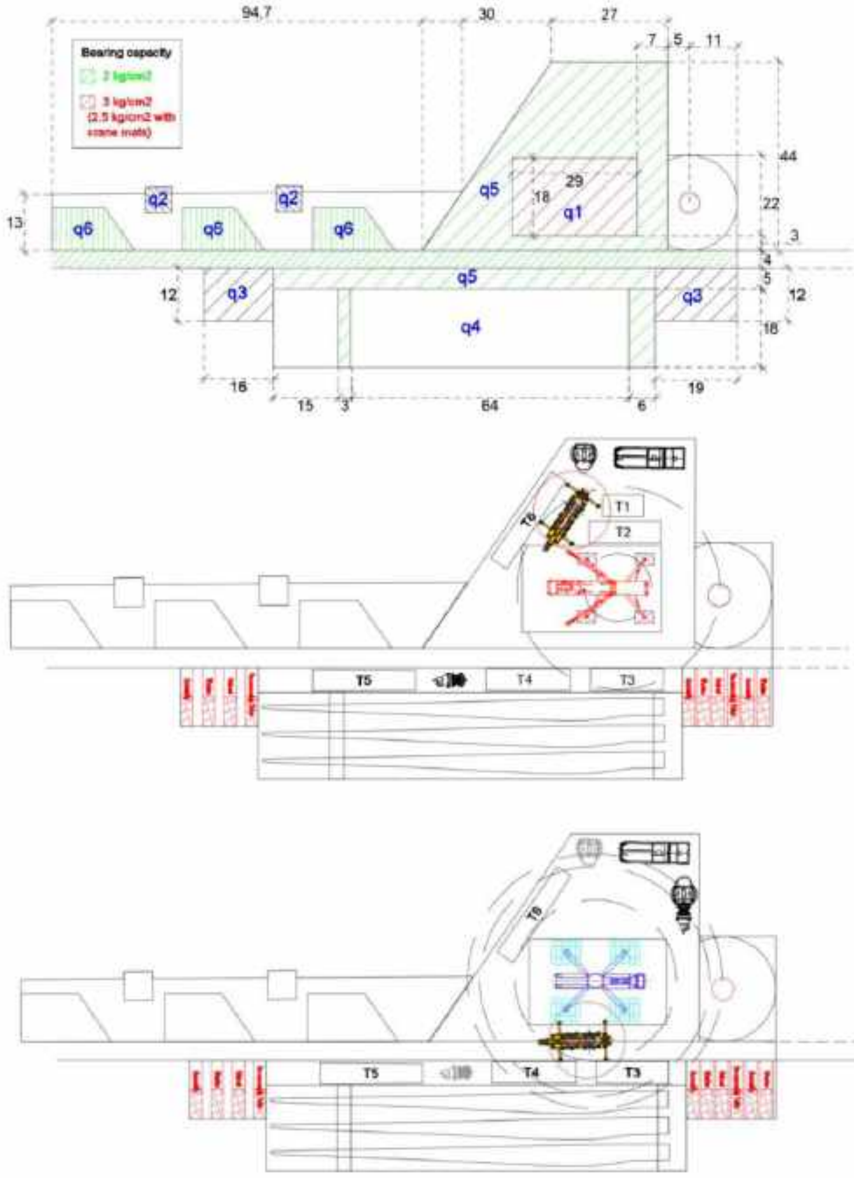

Figure 15 Model T110.5m – Partial storage assembling with strategy 3 in 2 phases

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5.4.4. T110.5m tubular steel tower Hardstand with strategy 4

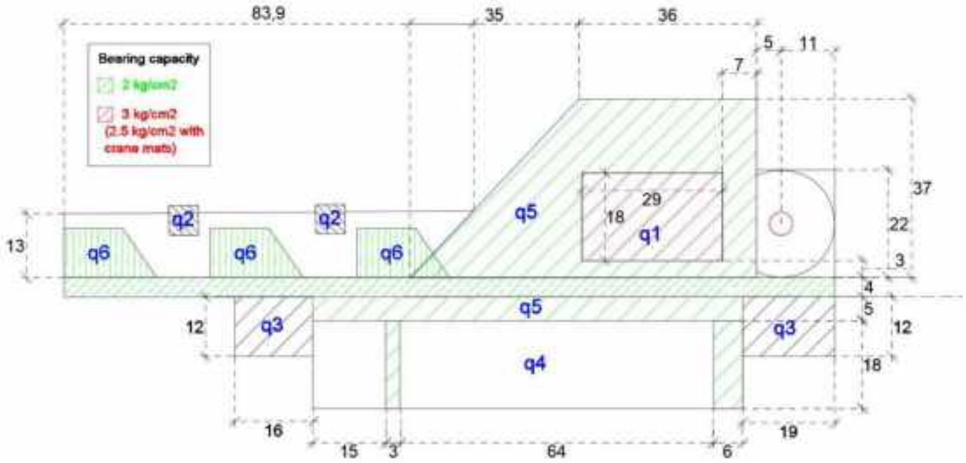
- Tailing crane offloading T110.5m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 36m x 37m + (35m x 37m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 28m x 37m + (35m x 37m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 30.13 Dimensions of the areas of model T110.5m with strategy 4 – Tailing crane offloading

*Referred to 3.1.4 Road width

- Total storage – Assembly in 1 phase



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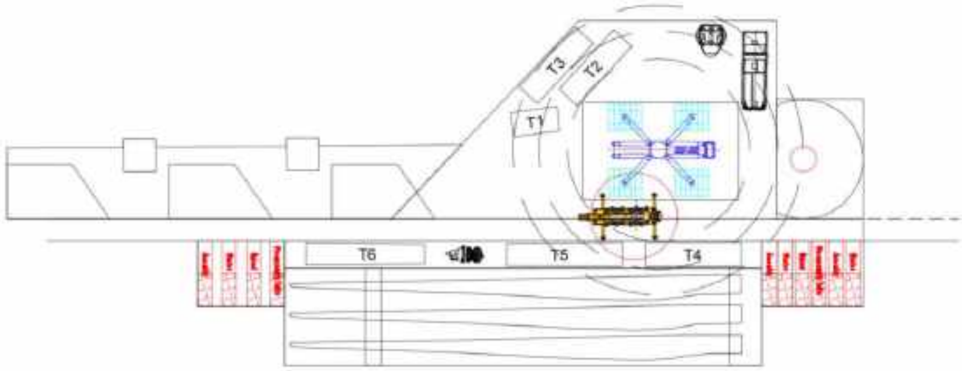
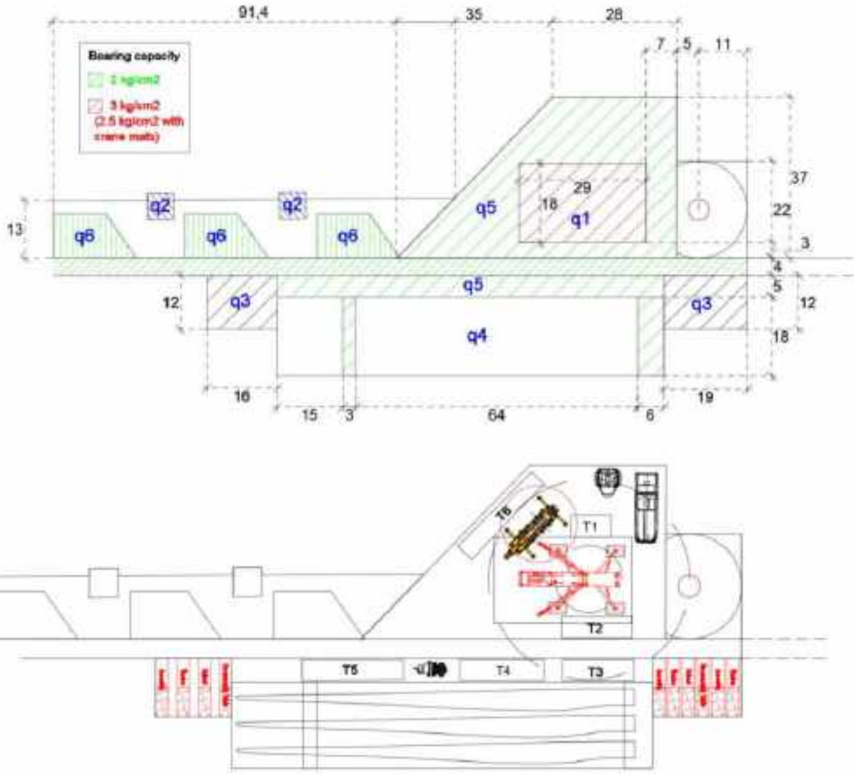


Figure 16 Model T110.5m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



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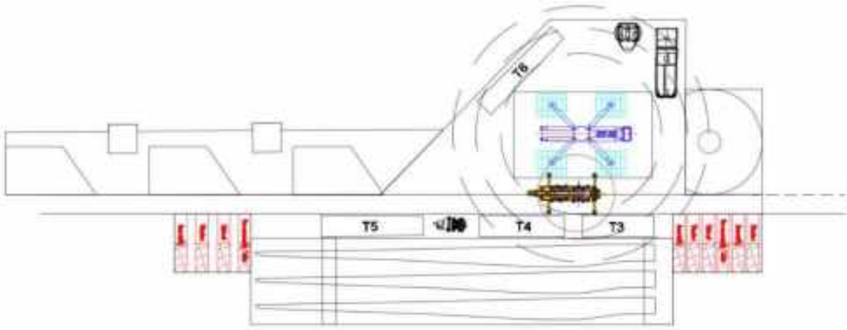

Figure 17 Model T110.5m – Parcial storage assembling with strategy 4 in 1 phase

5.4.5. T115m tubular steel tower Hardstand with strategy 3

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 34m x 43m + (46m x 43m)/2 – q1 +88m x 5m + reinforced road part* q2/q6 dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 33m x 43m + (36m x 43m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 141. Dimensions of the areas of model T115m with strategy 3 – Tailing crane offloading

*Referred to 3.1.4 Road width

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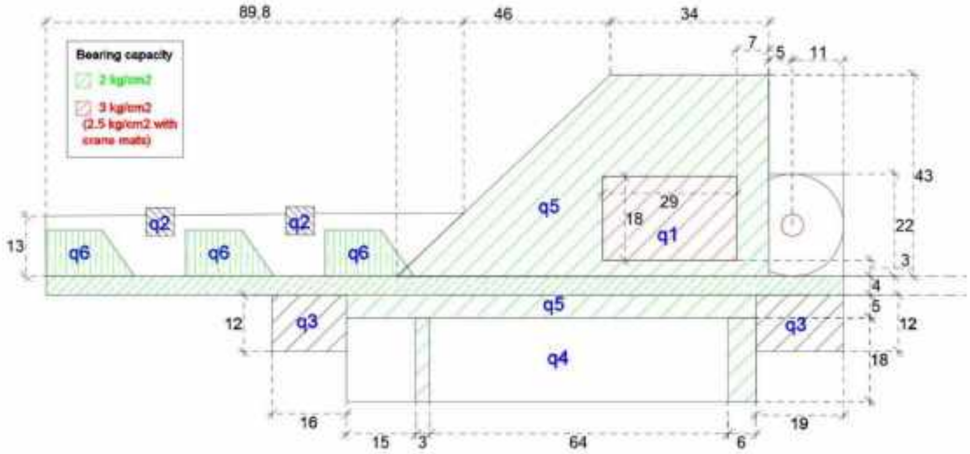
- Total storage – assembly in 1 phase



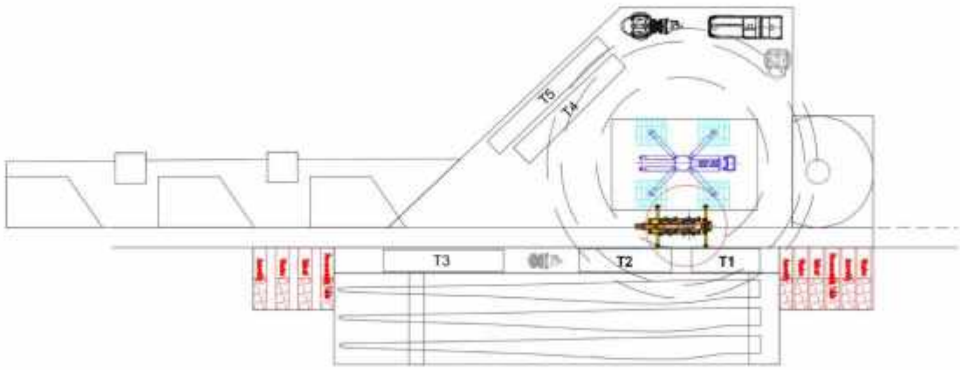


Figure 18 Model T115m – Total storage assembling with strategy 3 in 1 phase

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- Partial storage – Assembly in 2 phases (SGRE standard)

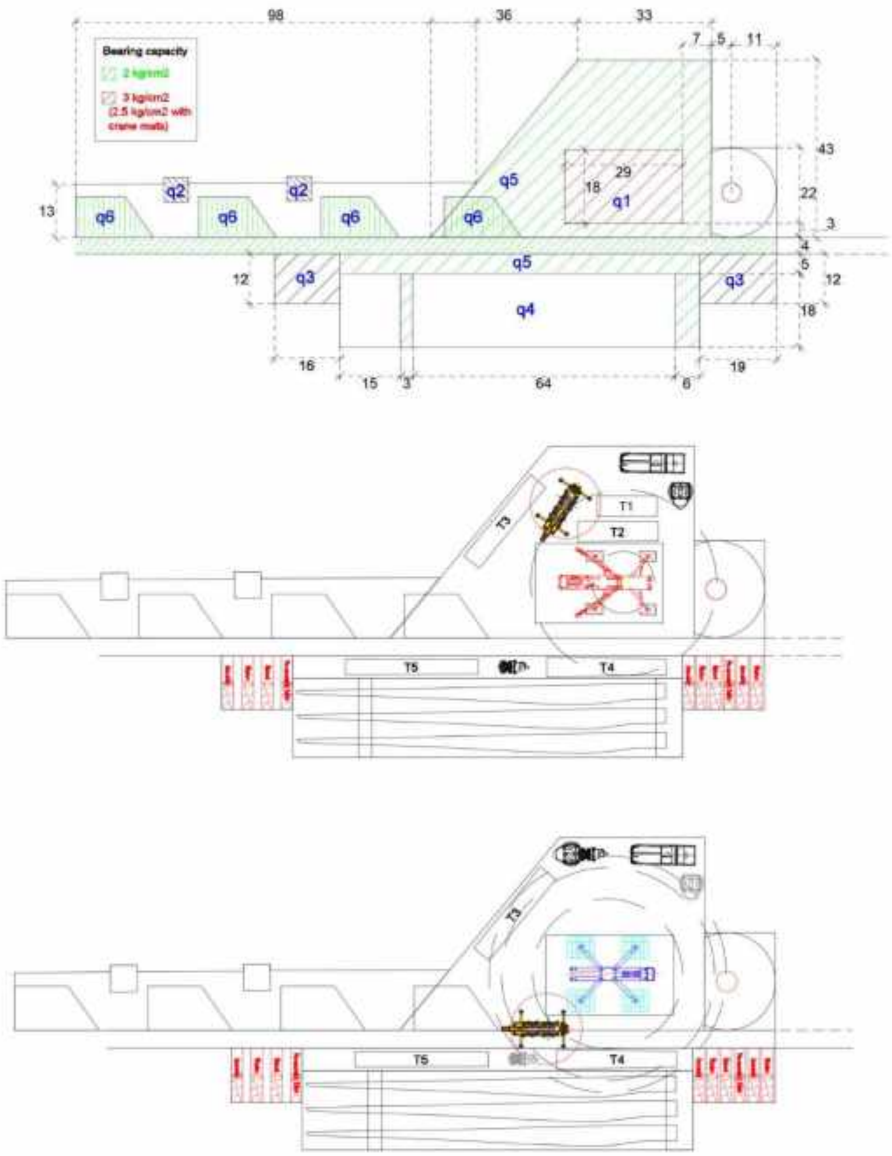

Figure 19 Model T115m – Partial storage assembling with strategy 3 in 2 phases

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5.4.6. T115m tubular steel tower Hardstand with strategy 4

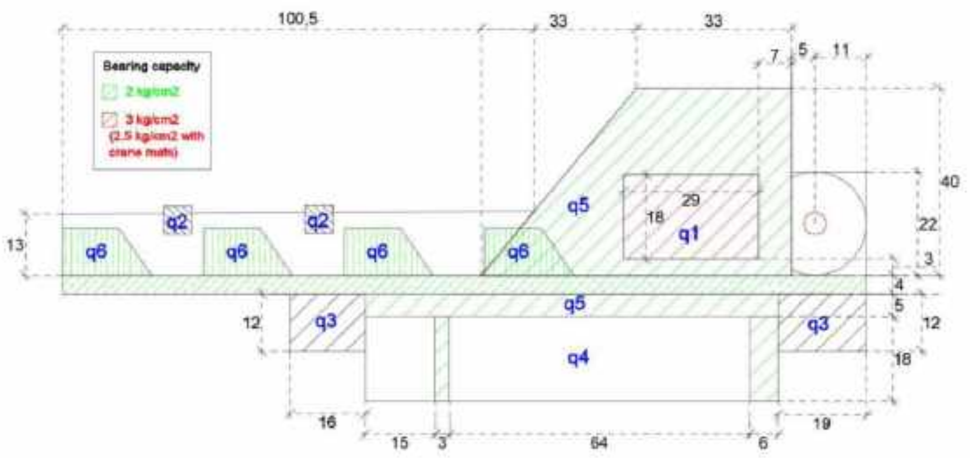
- Tailing crane offloading T115m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 33m x 40m + (33m x 40m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 30m x 38m + (31m x 38m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 32. Dimensions of the areas of model T115m with strategy 4 – Tailing crane offloading

*Referred to 3.1.4 Road width

- Total storage – Assembly strategy in 1 phase



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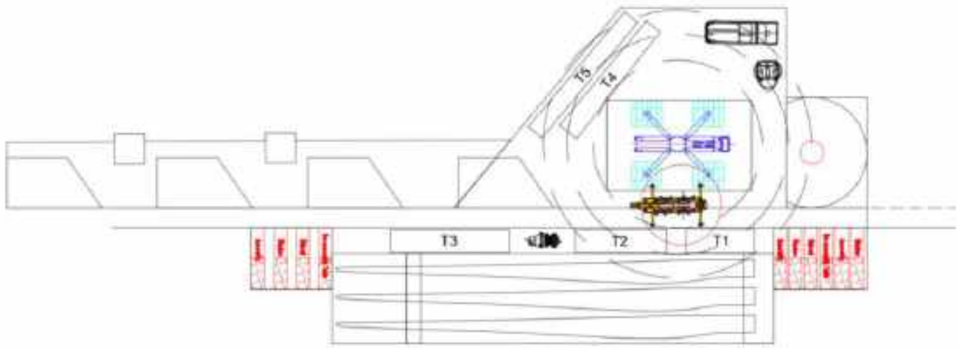
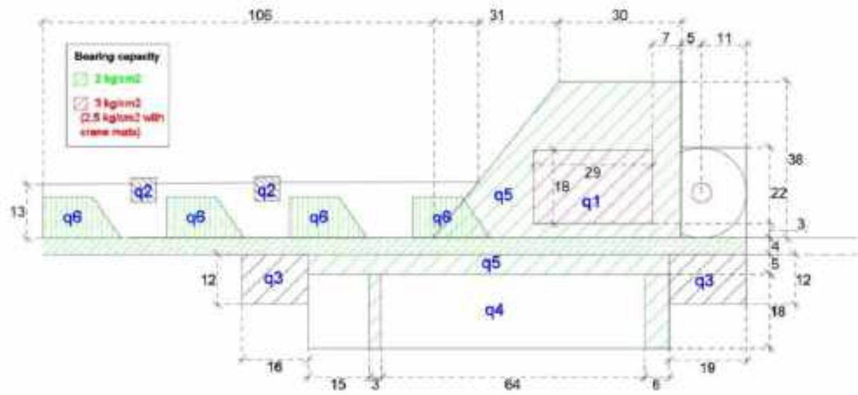
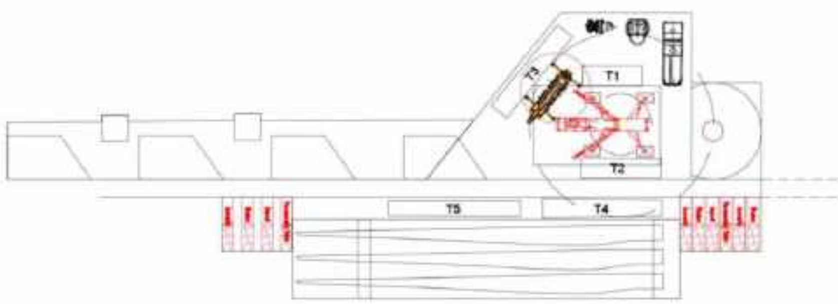


Figure 20 Model T115m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)





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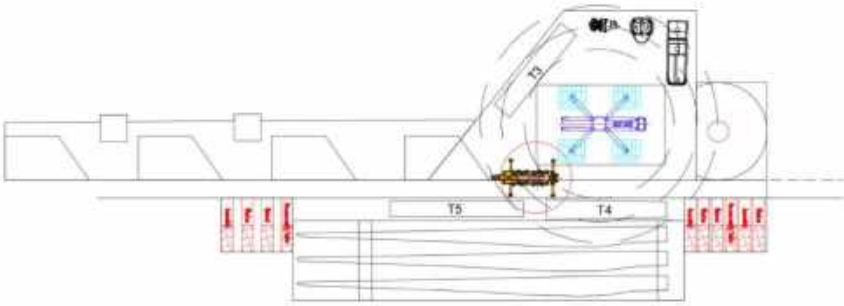

Figure 21 Model T115m – Partial storage assembling with strategy 4 in 2 phases

5.4.7. T135m (52A) tubular steel tower Hardstand with strategy 3

- Tailing crane offloading T135m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 50m x 44m + (45m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6 dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 45m + (28m x 45m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 33. Dimensions of the areas of model T135m (52A) with strategy 3 – Tailing crane offloading

*Referred to 3.1.4 Road width

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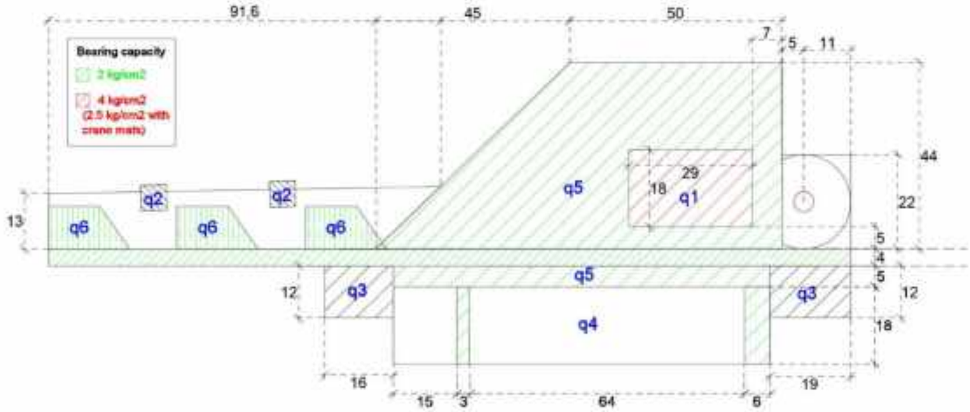
- Total storage – Assembly in 1 phase – STD tower



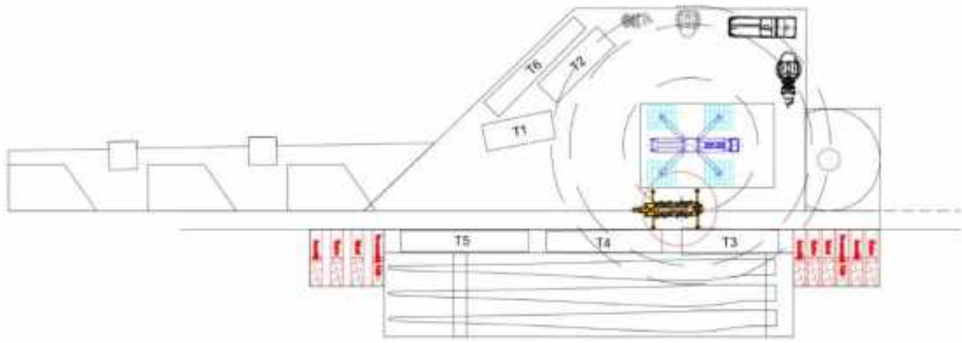


Figure 22. Model T135m (52A) – Total storage assembling with strategy 3 in 1 phase

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- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower

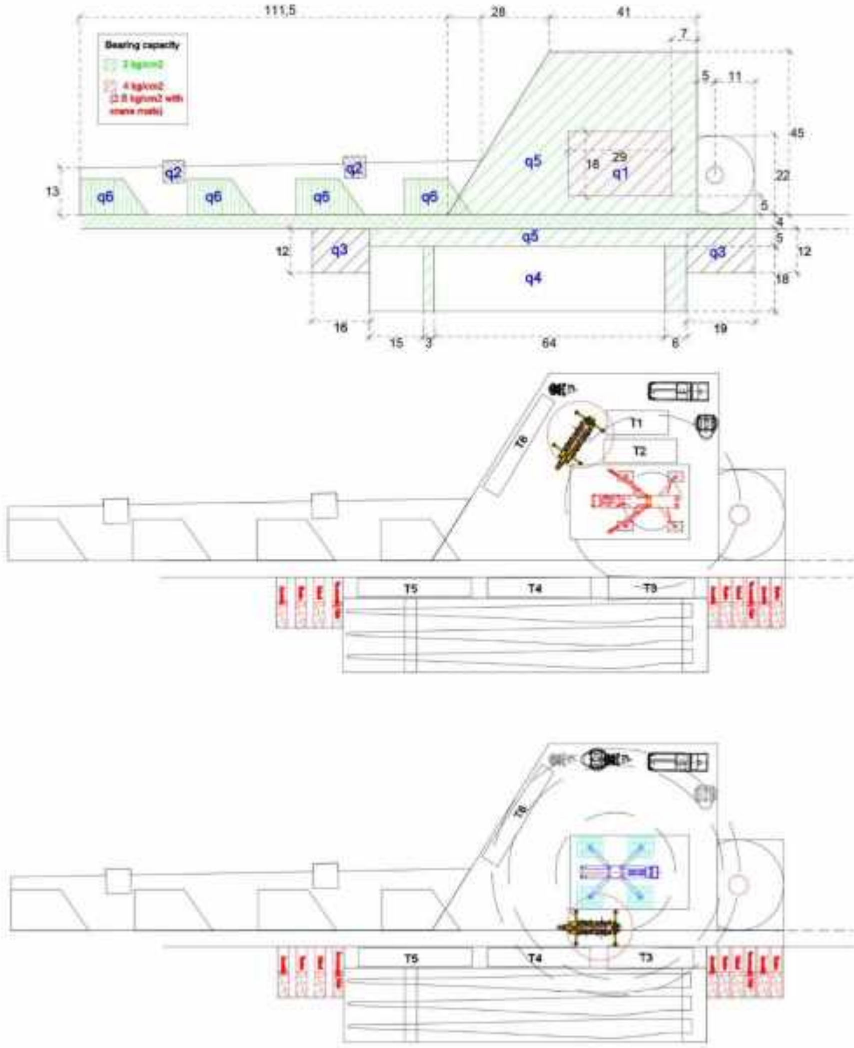

Figure 23. Model T135m (52A) - Partial storage assembling with strategy 3 in 2 phases

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5.4.8. T135m (52A) tubular steel tower Hardstand with strategy 4

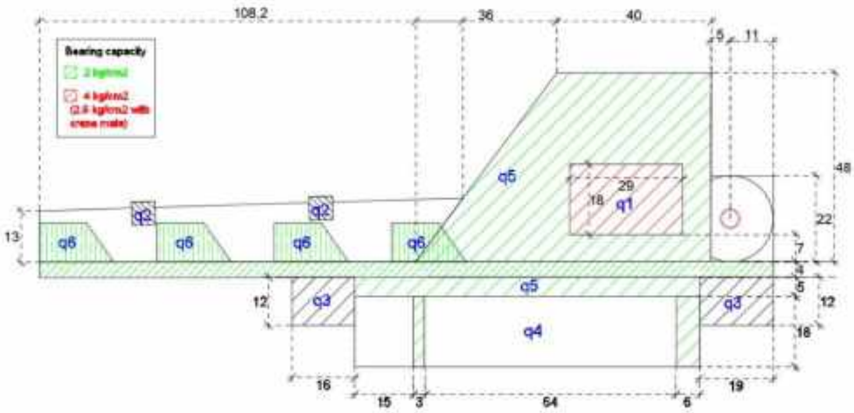
- Tailing crane offloading T135m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 40m x 48m + (36m x 48m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 32m x 48m + (36m x 48m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 3415. Dimensions of the areas of model T135m (52A) with strategy 4 – Tailing crane offloading

- Total storage – Assembly in 1 phase



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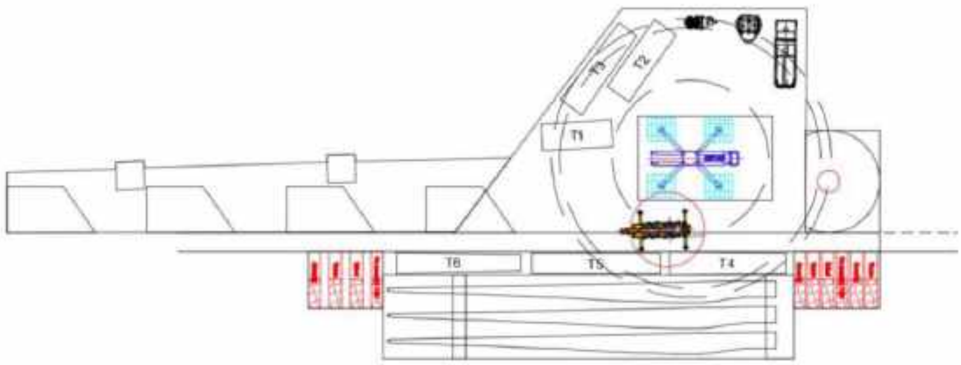
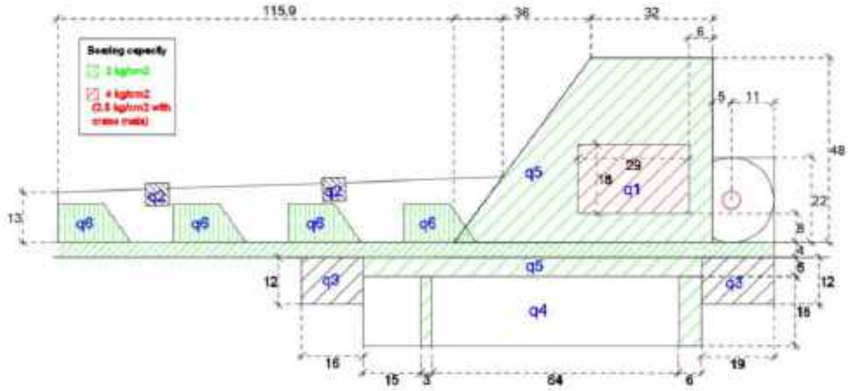
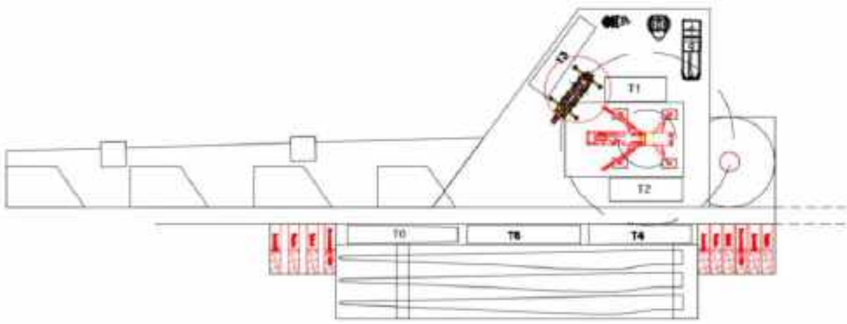


Figure 24. Model T135m (52A) – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)





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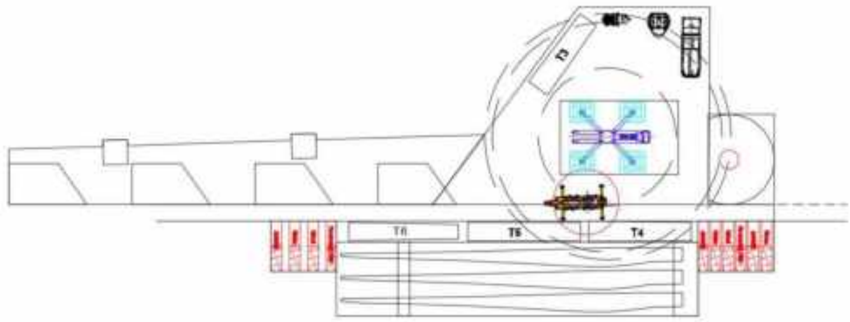

Figure 25. Model T135m (52A) - Partial storage assembling with strategy 4 in 2 phases

5.4.9. T135m (54A) tubular steel tower Hardstand with strategy 3

- Tailing crane offloading T135m

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 50m x 44m + (45m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 45m + (28m x 45m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 35. Dimensions of the areas of model T135m (54A) with strategy 3 – Tailing crane offloading

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- Total storage – Assembly in 1 phase – STD tower

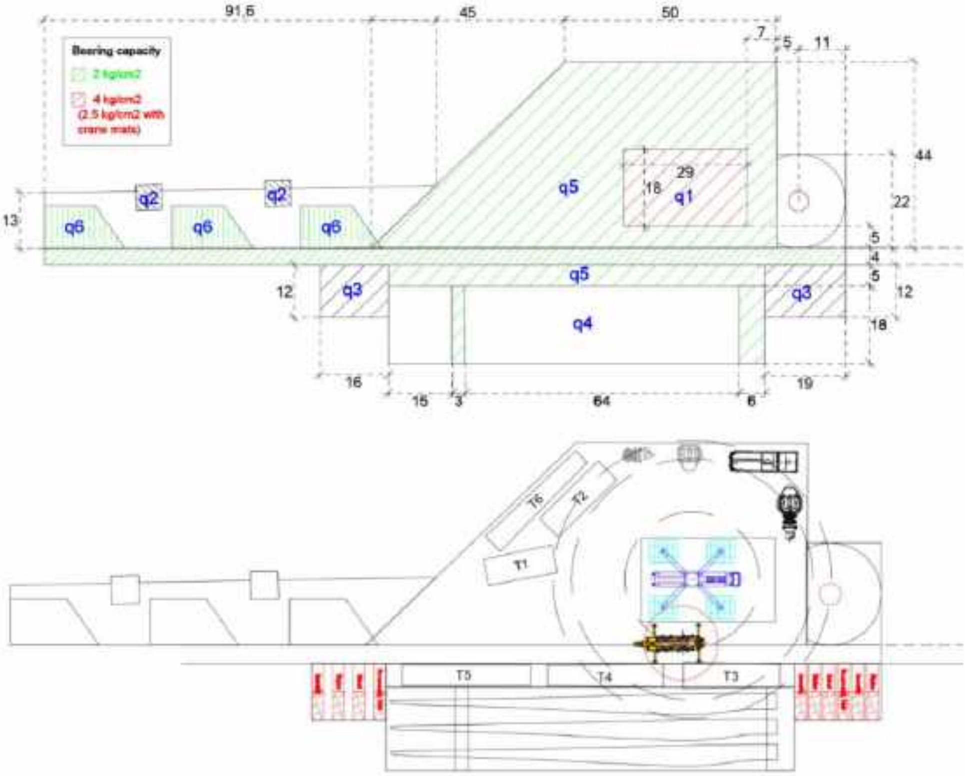
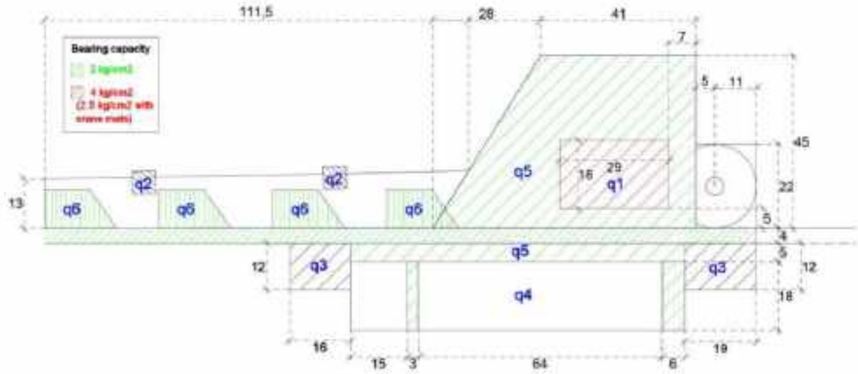


Figure 26. Model T135m (54A) – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



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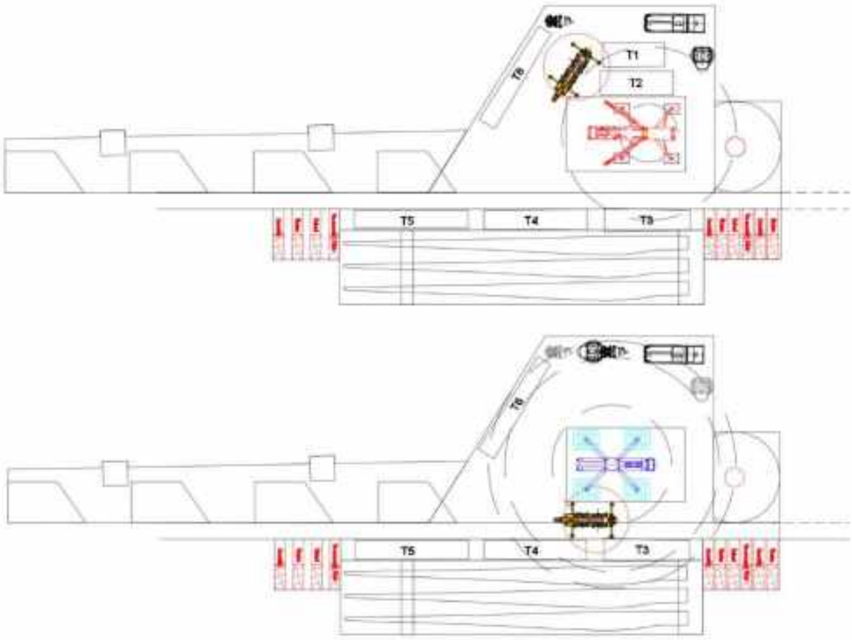

Figure 27. Model T135m (54A) - Partial storage assembling with strategy 3 in 2 phases

5.4.10. T135m (54A) tubular steel tower Hardstand with strategy 4

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 50m x 44m + (45m x 44m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 45m + (28m x 45m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 36. Dimensions of the areas of model T135m (54A) with strategy 4 – Tailing crane offloading

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- Total storage – Assembly in 1 phase – STD tower

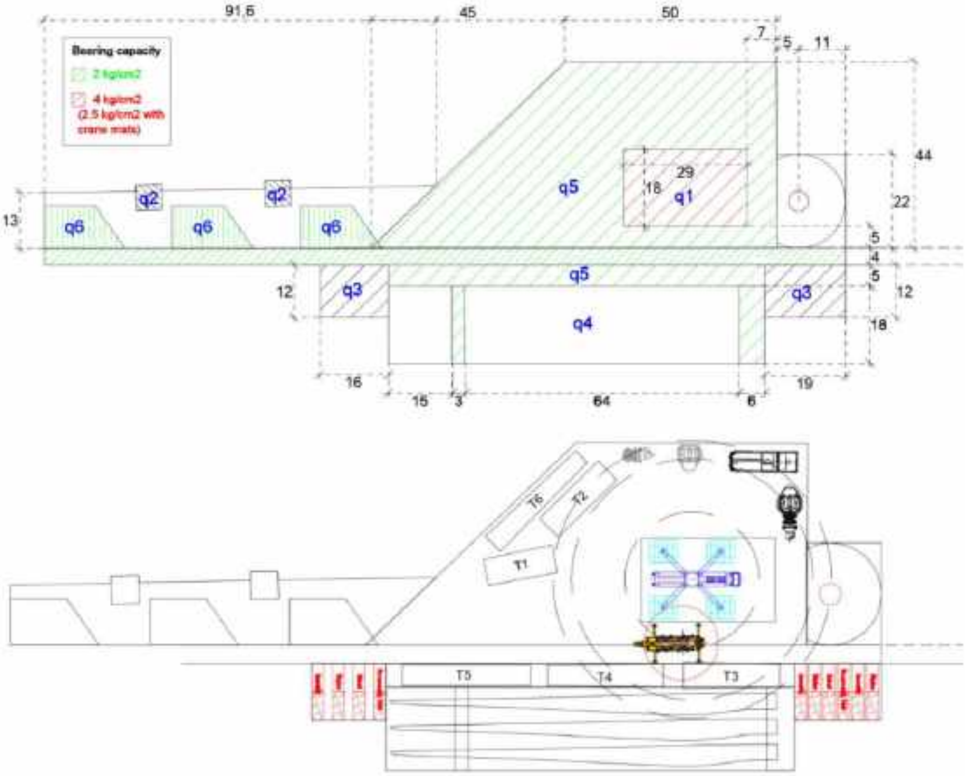
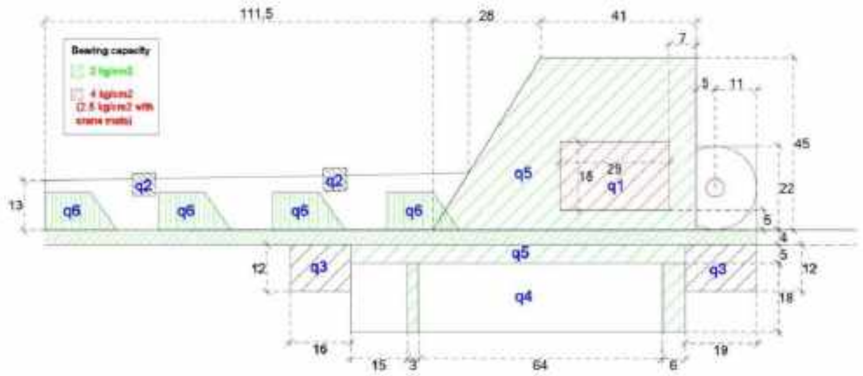


Figure 28. Model T135m (54A) – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



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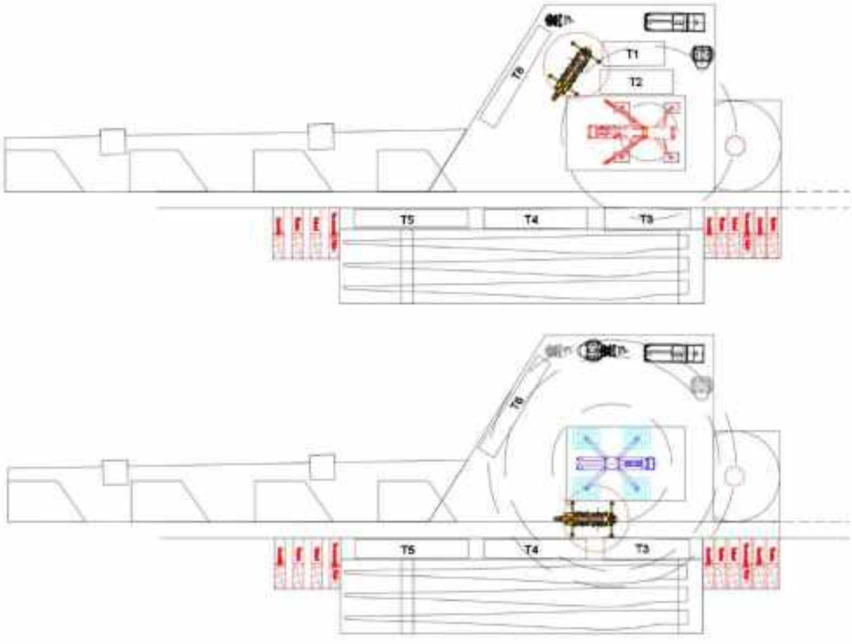

Figure 22. Model T135m (54A) - Partial storage assembling with strategy 4 in 2 phases

5.4.11. T145m tubular steel tower Hardstand with strategy 3

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 26m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 60m x 51m + (38m x 51m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 47m x 52m + (44m x 52m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 37. Dimensions of the areas of model T145m with strategy 3 – Tailing crane offloading

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- Total storage – Assembly in 1 phase – STD tower

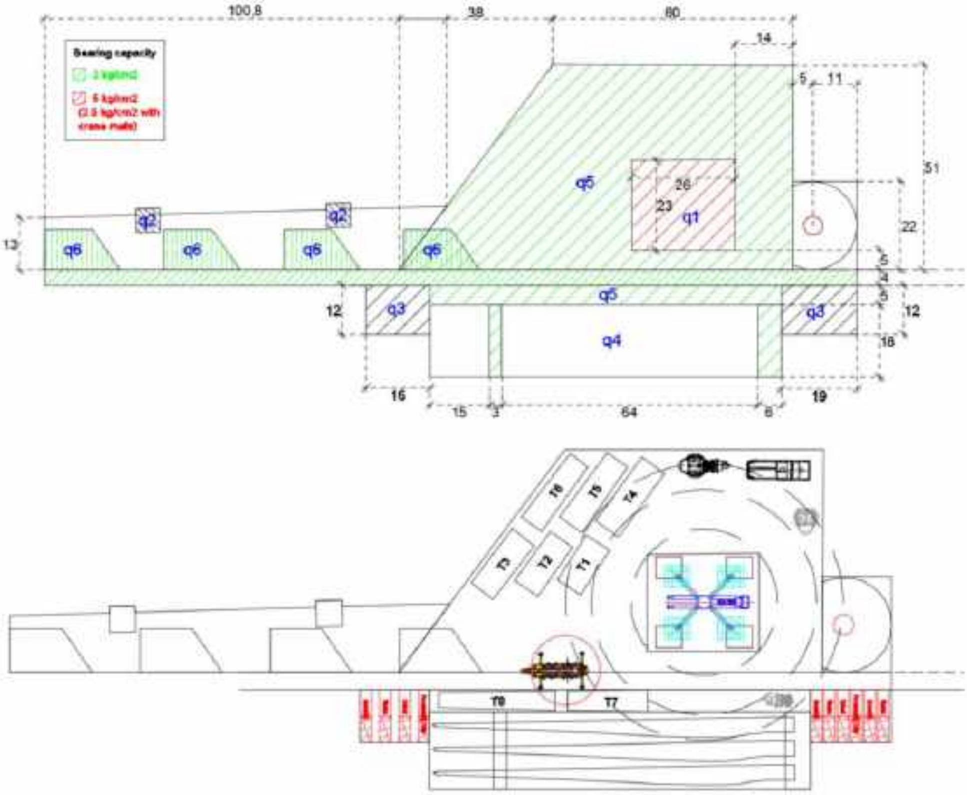
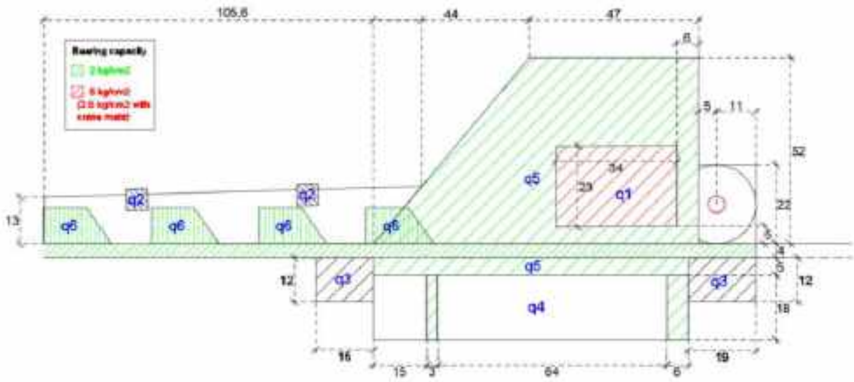


Figure 30. Model T145m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



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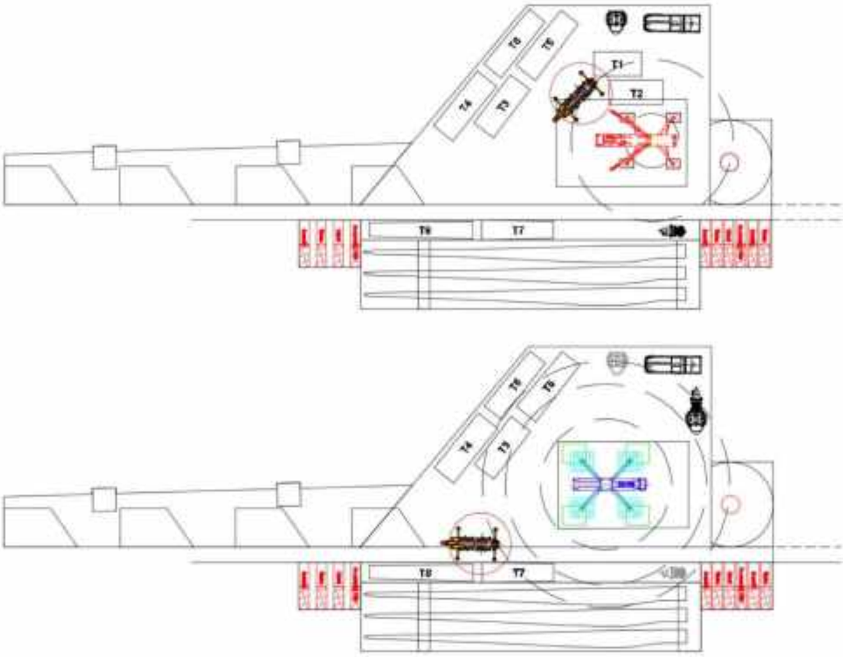

Figure 31. Model T145m - Partial storage assembling with strategy 3 in 2 phases

5.4.12. T145m tubular steel tower Hardstand with strategy 4

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 39m x 49m + (41m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 38. Dimensions of the areas of model T145m with strategy 4 – Tailing crane offloading

*Referred to 3.1.4 Road width

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- Total storage – Assembly in 1 phase – STD tower

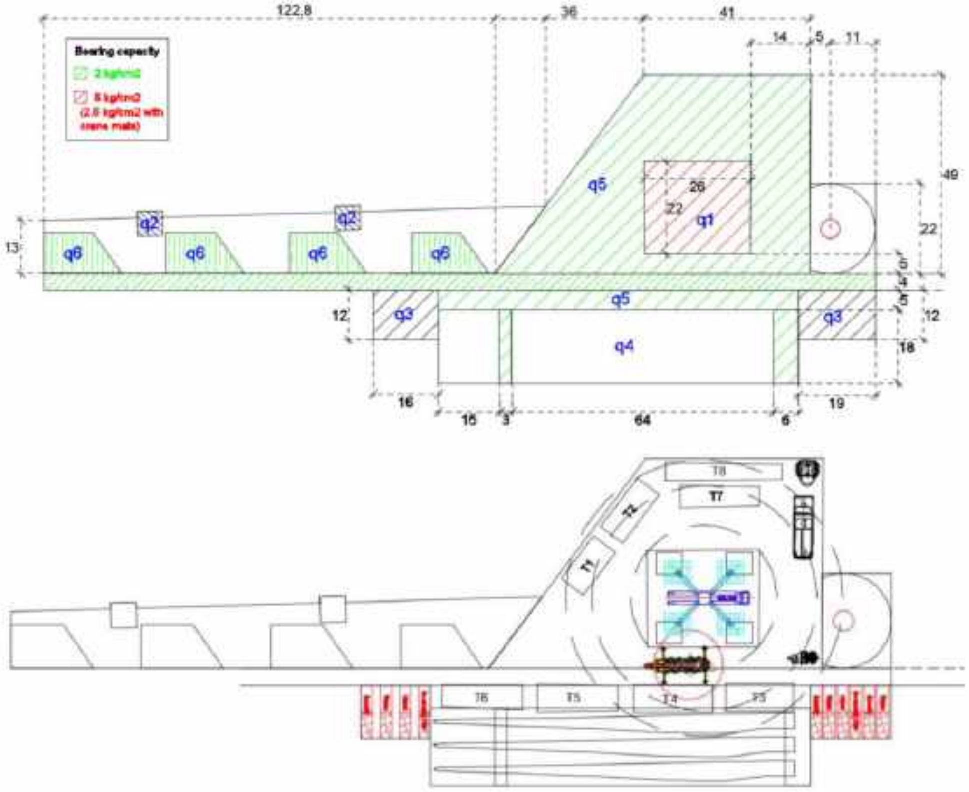
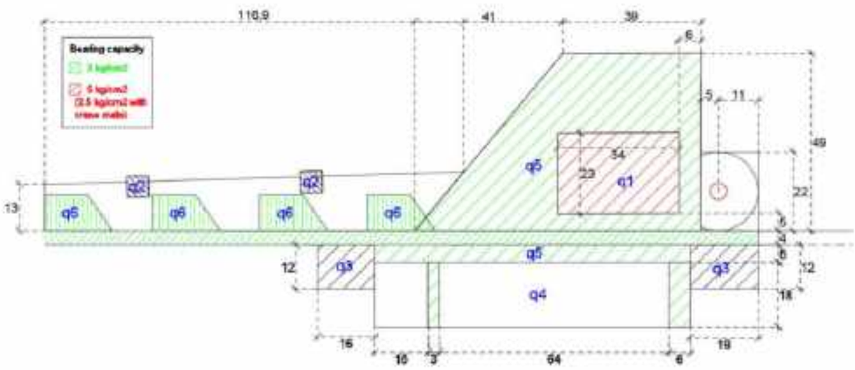


Figure 32. Model T145m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



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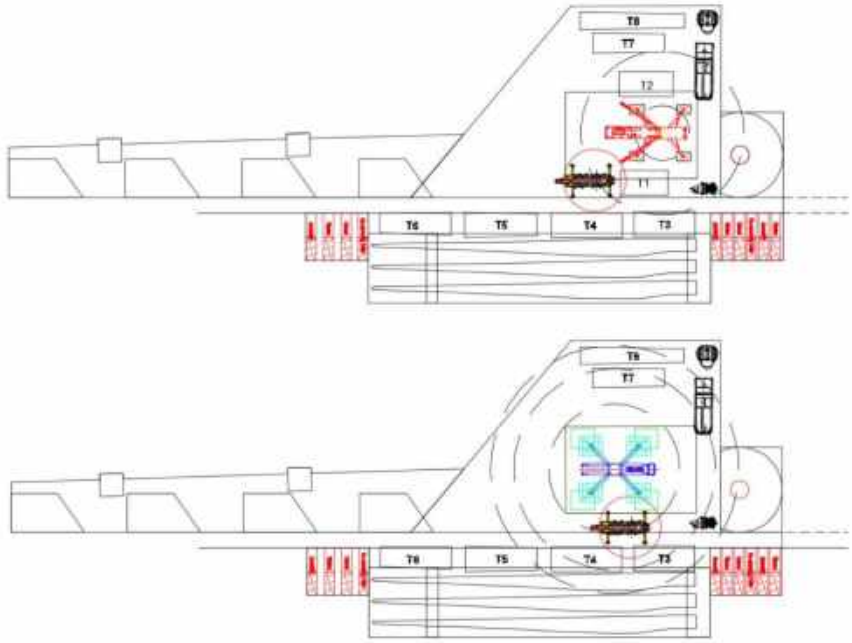

Figure 33. Model T145m - Partial storage assembling with strategy 4 in 2 phases

5.4.13. T150m tubular steel tower Hardstand with strategy 3

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 26m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 60m x 51m + (38m x 51m)/2 – q1 +88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 47m x 52m + (44m x 52m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 39. Dimensions of the areas of model T150m with strategy 3 – Tailing crane offloading

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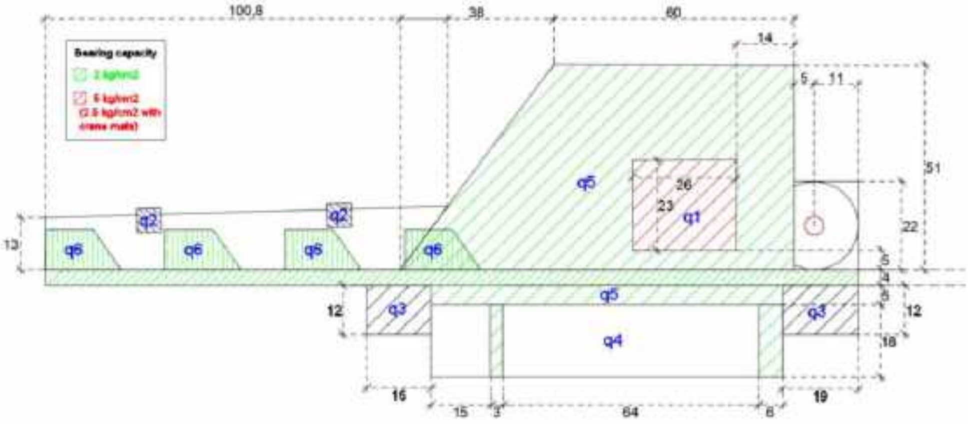
- Total storage – Assembly in 1 phase – STD tower



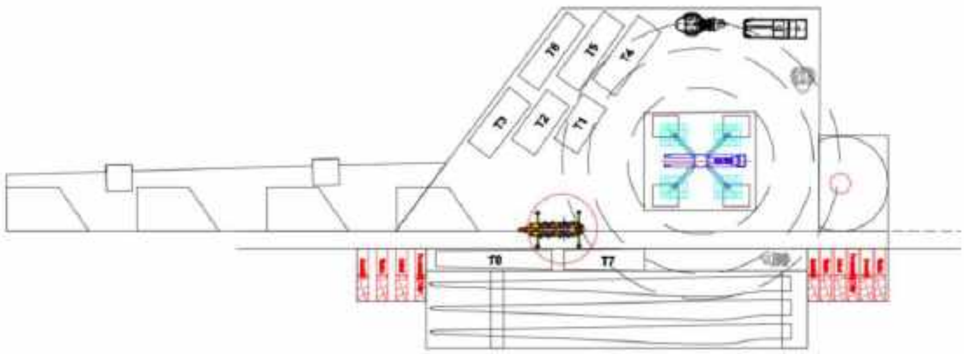
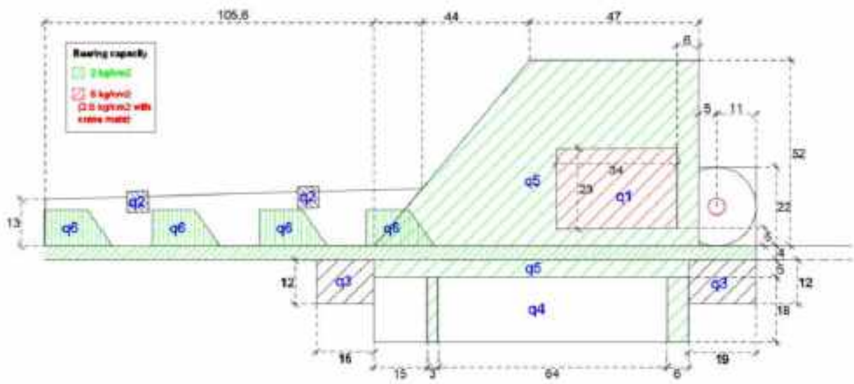


Figure 34. Model T150m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



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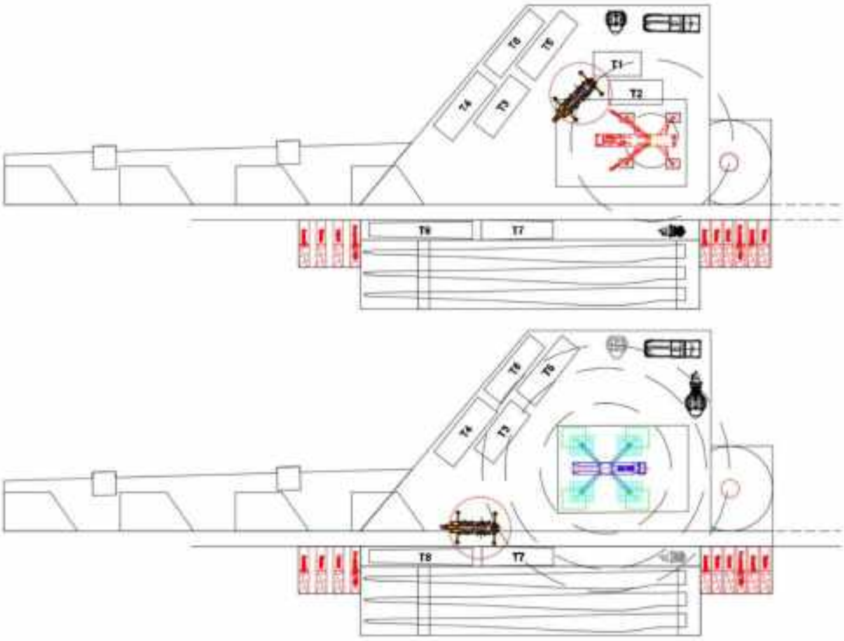

Figure 35. Model T150m - Partial storage assembling with strategy 3 in 2 phases

5.4.14. T150m tubular steel tower Hardstand with strategy 4

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 39m x 49m + (41m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 40. Dimensions of the areas of model T150m with strategy 4 – Tailing crane offloading

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- Total storage – Assembly in 1 phase – STD tower

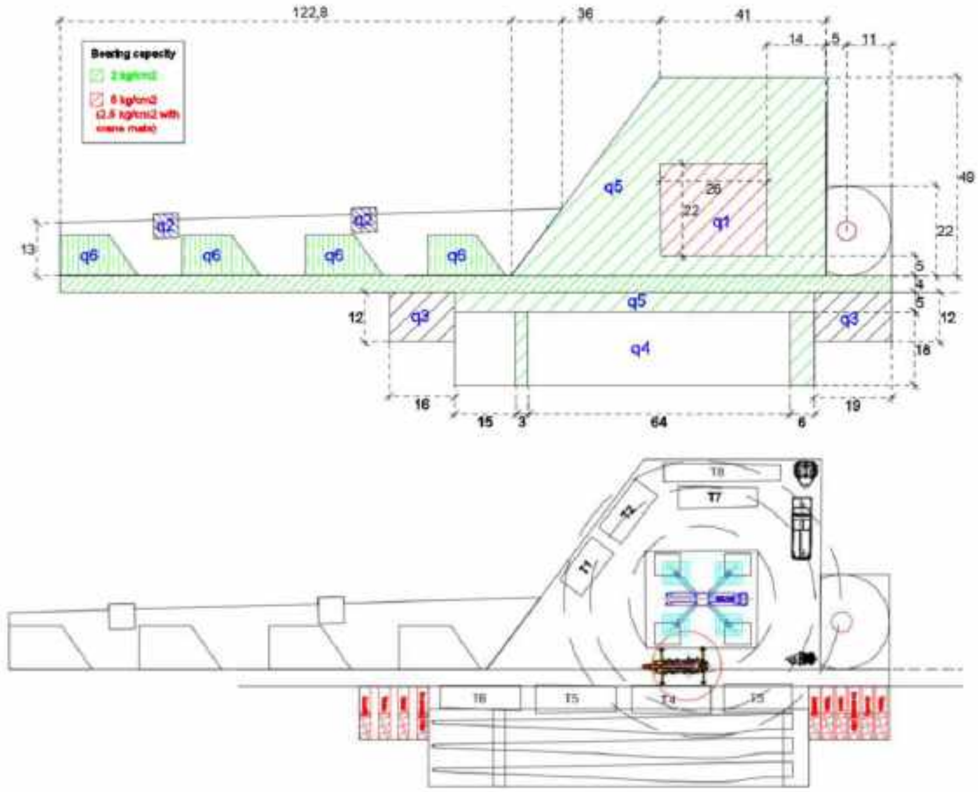
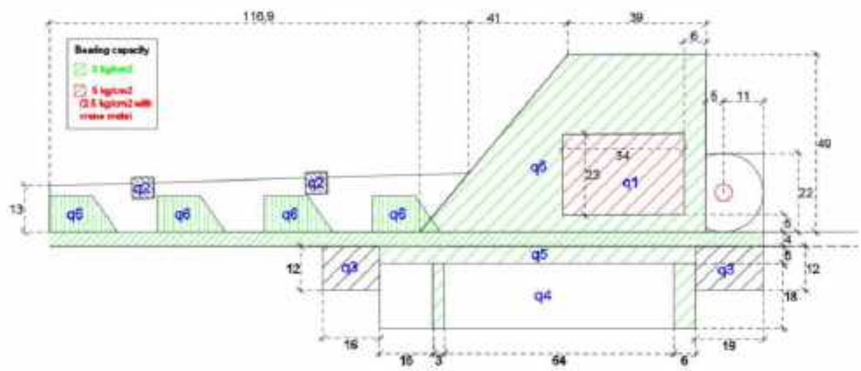


Figure 36. Model T150m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



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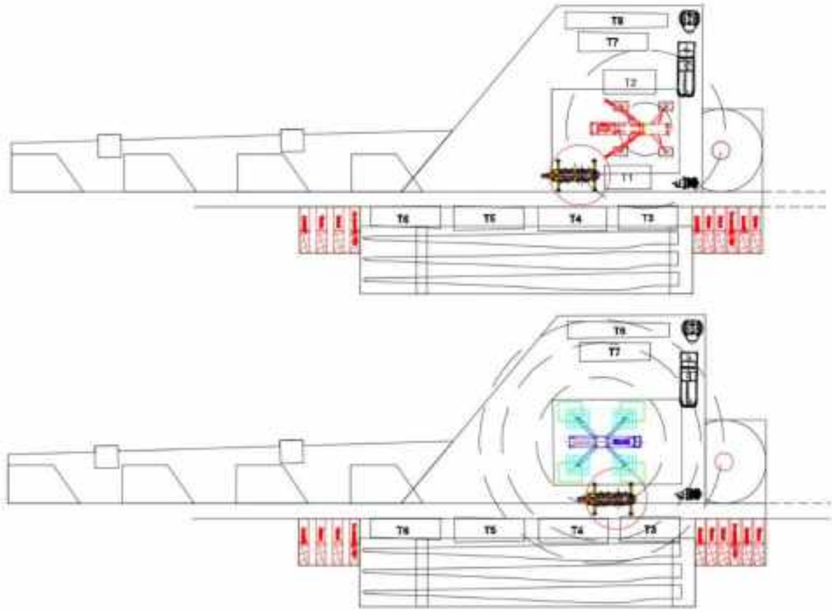

Figure 37. Model T150m - Partial storage assembling with strategy 4 in 2 phases

5.4.15. T155m tubular steel tower Hardstand with strategy 3

The sizing of the hardstand corresponds to the use of a large wide track crawler crane and not the standard crane LG1750.

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 51m x 51m + (38m x 51m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 53m x 46m + (38m x 56m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 41. Dimensions of the areas of model T155m with strategy 3 – Tailing crane offloading

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- Total storage – Assembly in 1 phase – STD tower

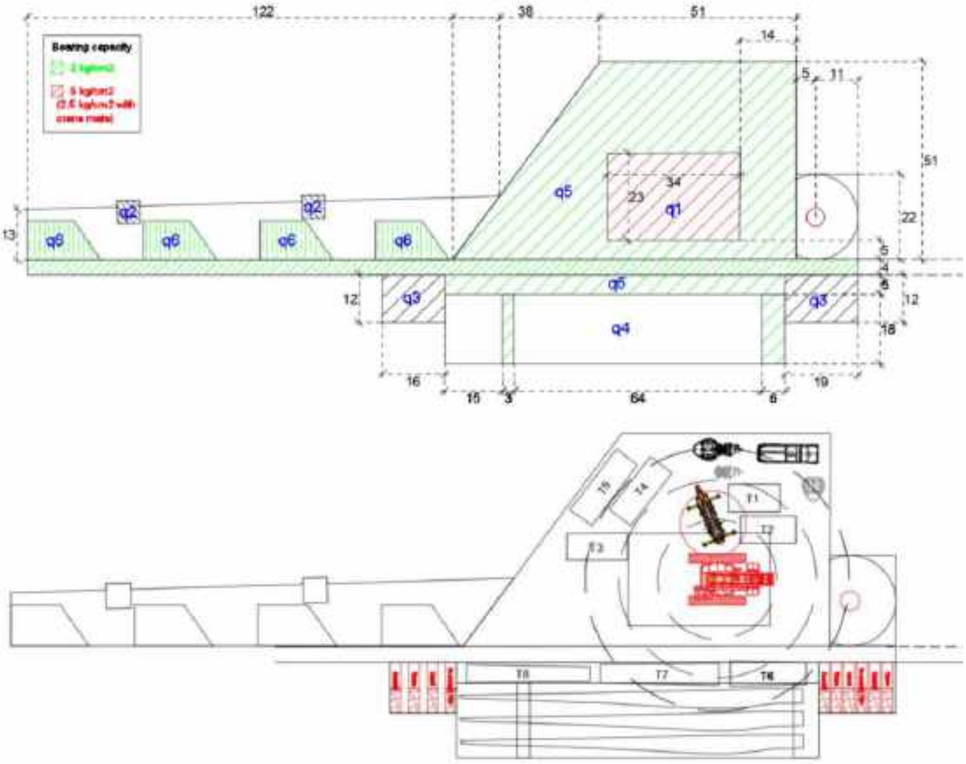
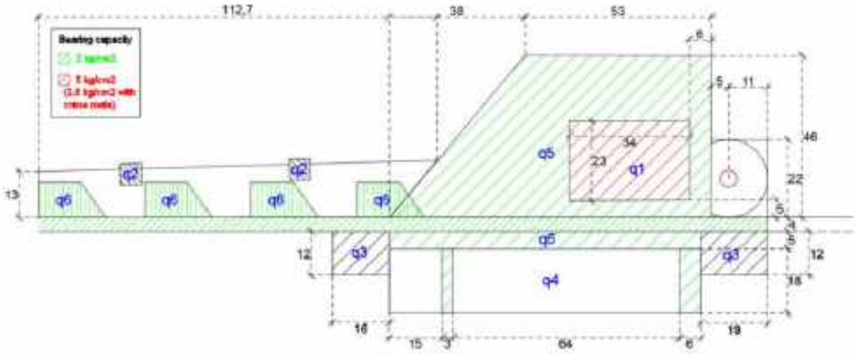


Figure 38. Model T155m – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



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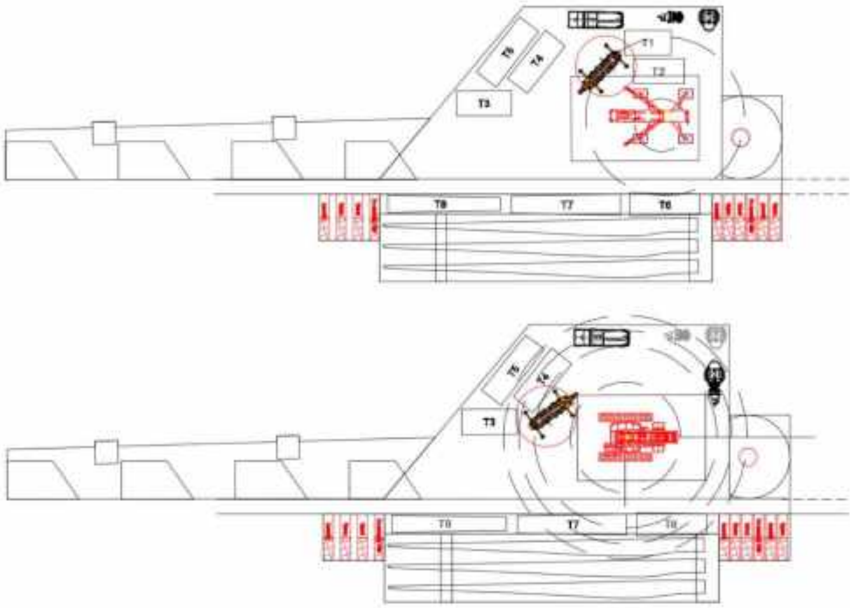

Figure 23. Model T155m - Partial storage assembling with strategy 3 in 2 phases

5.4.16. T155m tubular steel tower Hardstand with strategy 4

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 42. Dimensions of the areas of model T155m with strategy 4 – Tailing crane offloading

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- Total storage – Assembly in 1 phase – STD tower

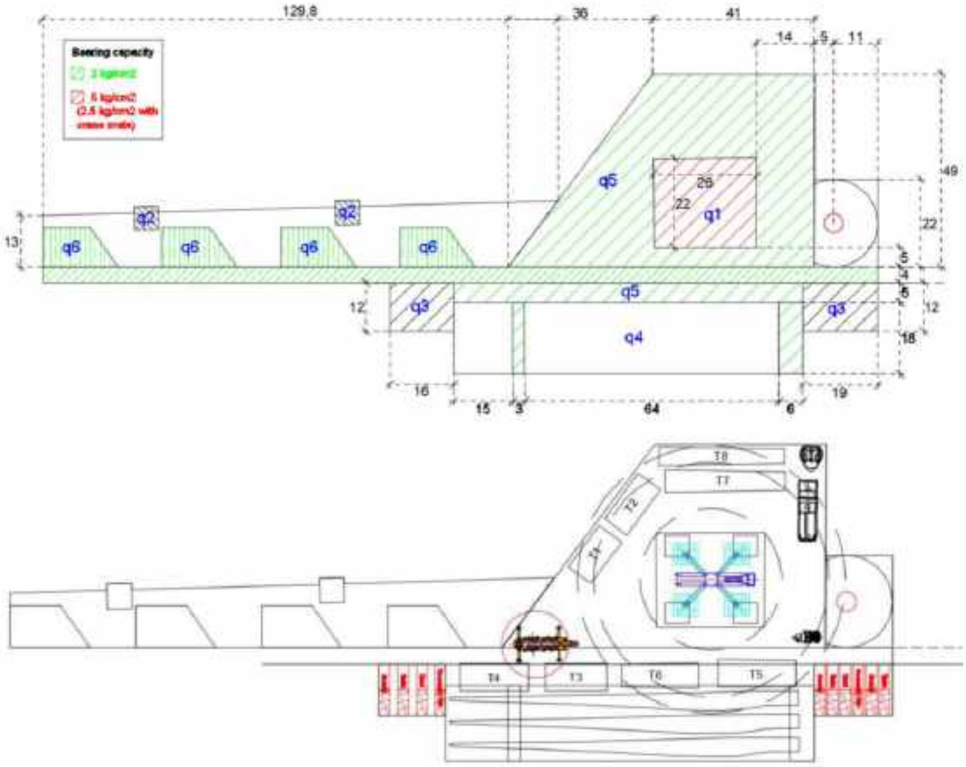
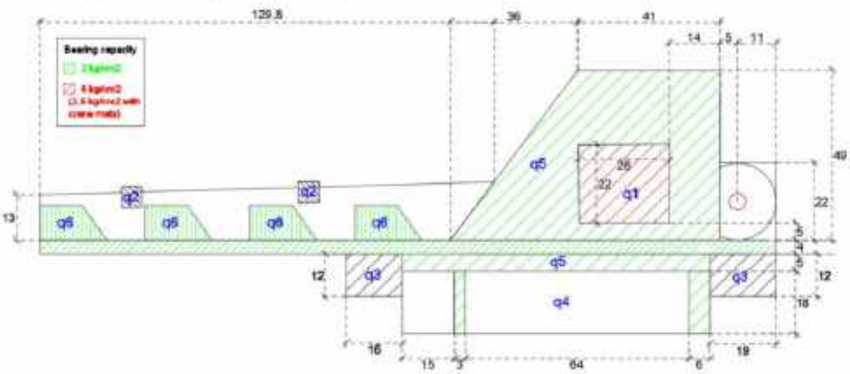


Figure 40. Model T155m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower



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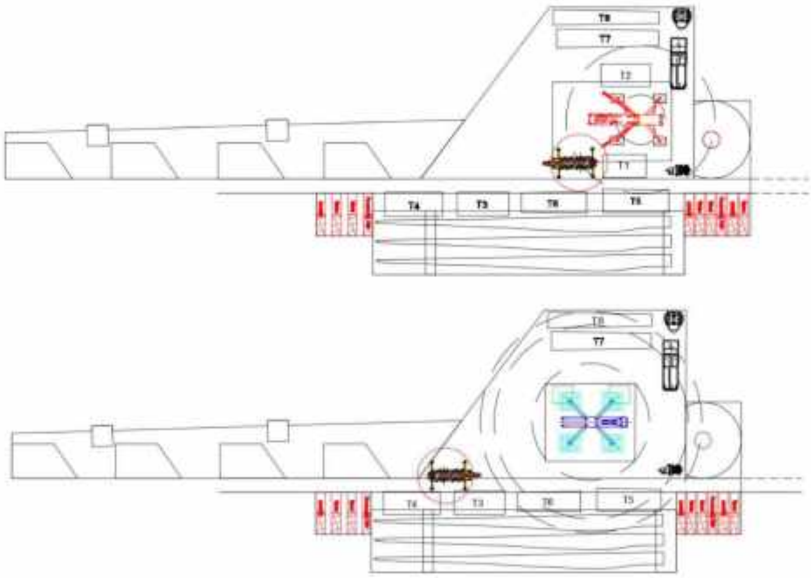

Figure 41. Model T155m - Partial storage assembling with strategy 4 in 2 phases

5.4.17. T165m tubular steel tower Hardstand with strategy 3

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 51m x 51m + (38m x 51m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 53m x 46m + (38m x 56m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 16 Dimensions of the areas of model T155m with strategy 3 – Tailing crane offloading

*Referred to 3.1.4 Road width

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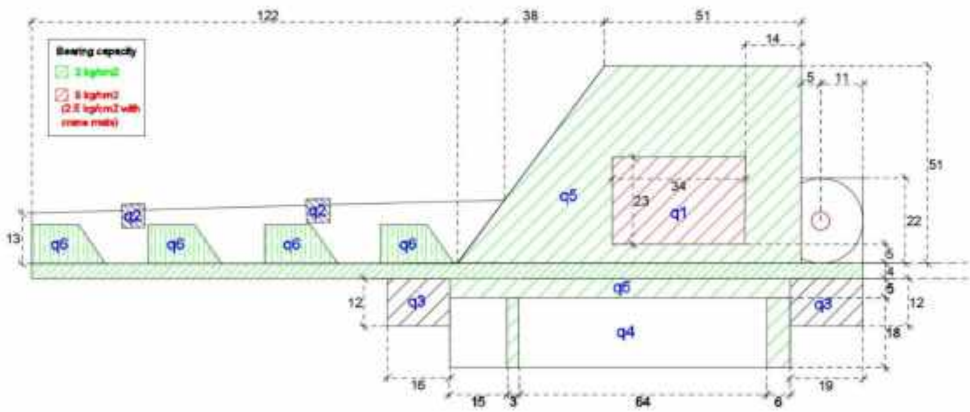
- Total storage – Assembly in 1 phase – STD tower



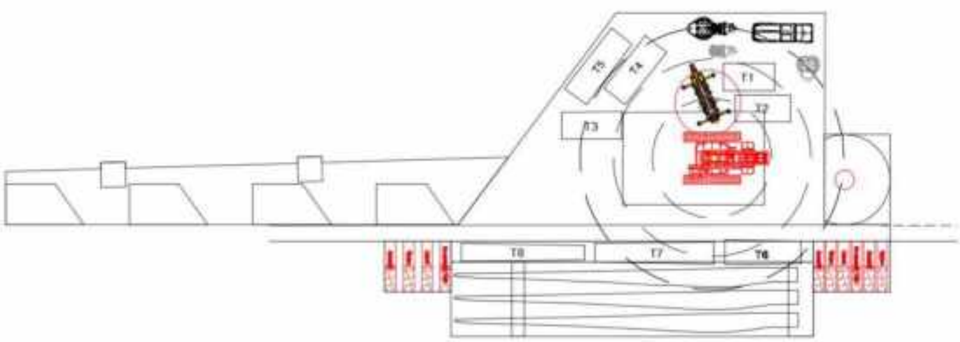


Figure 24 Model T155m – Total storage assembling with strategy 3 in 1 phase

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- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower

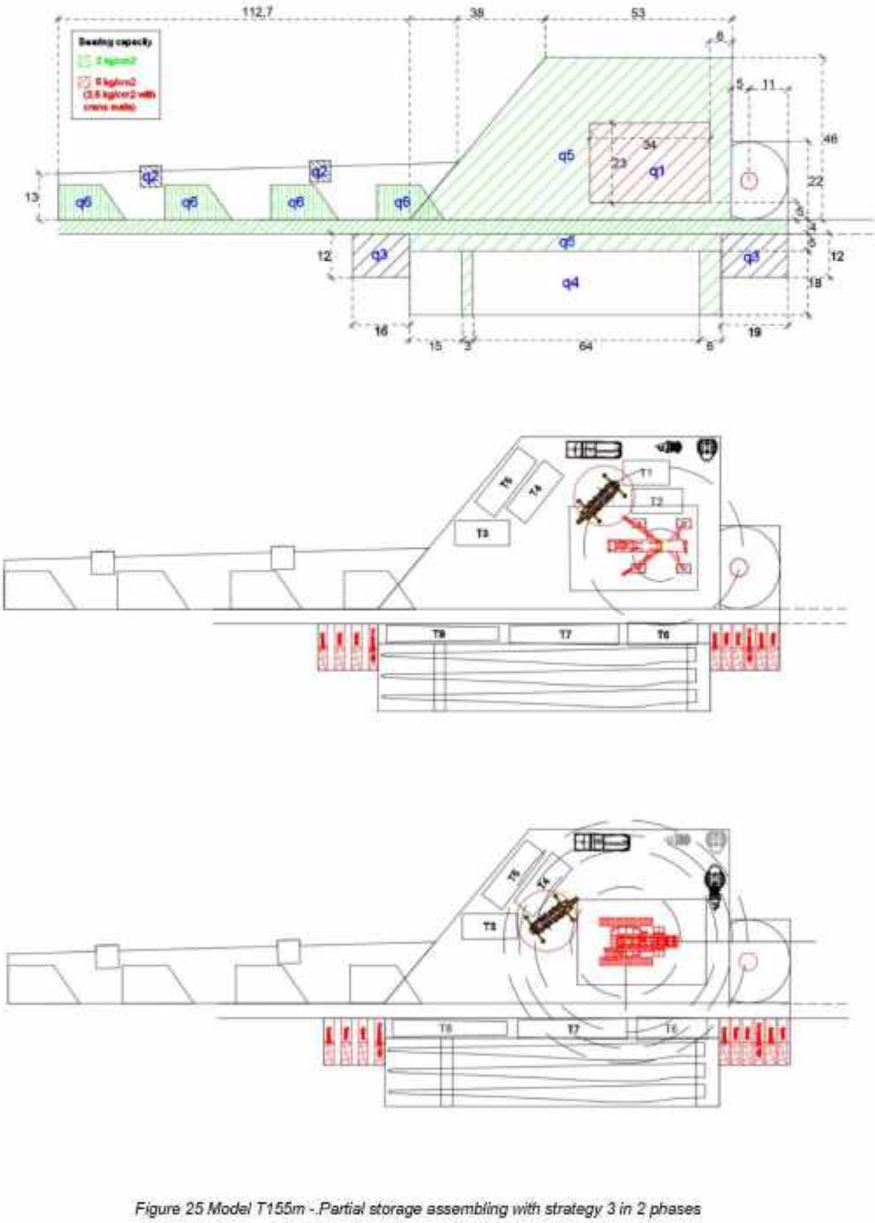

Figure 25 Model T155m -.Partial storage assembling with strategy 3 in 2 phases

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5.4.18. T165m tubular steel tower Hardstand with strategy 4

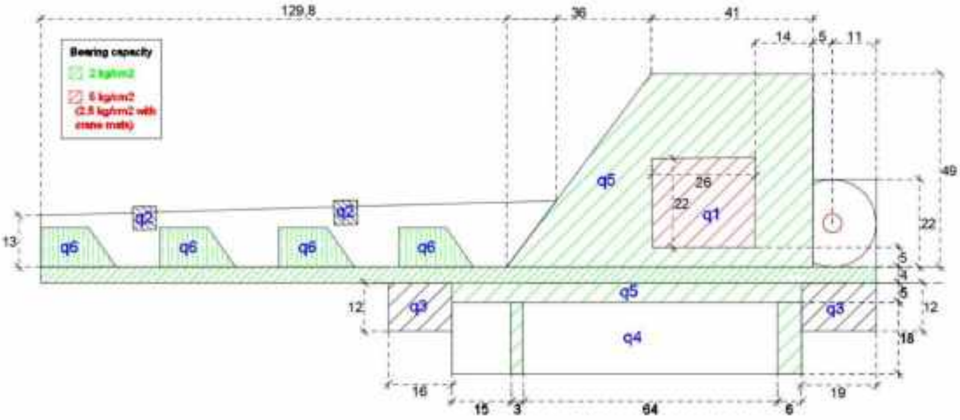
- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 26m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 41m x 49m + (36m x 49m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 17 Dimensions of the areas of model T155m with strategy 4 – Tailing crane offloading

*Referred to 3.1.4 Road width

- Total storage – Assembly in 1 phase – STD tower



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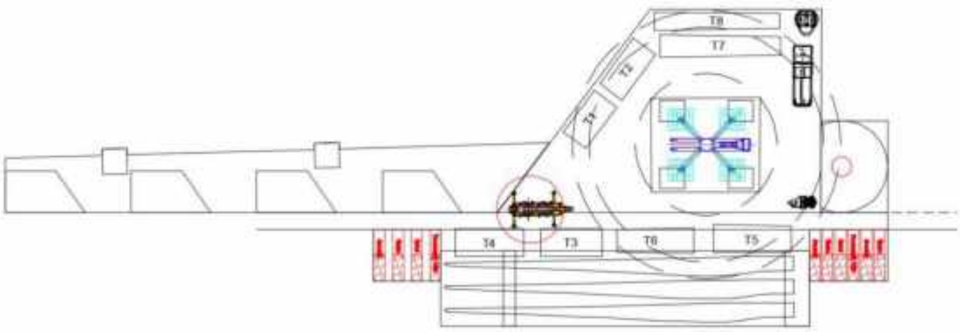
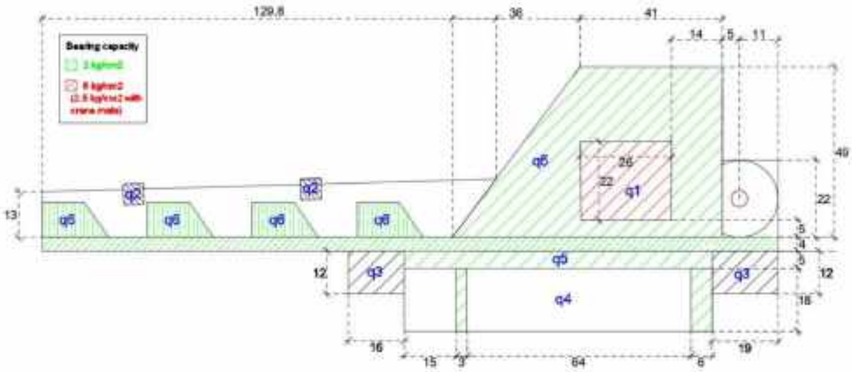
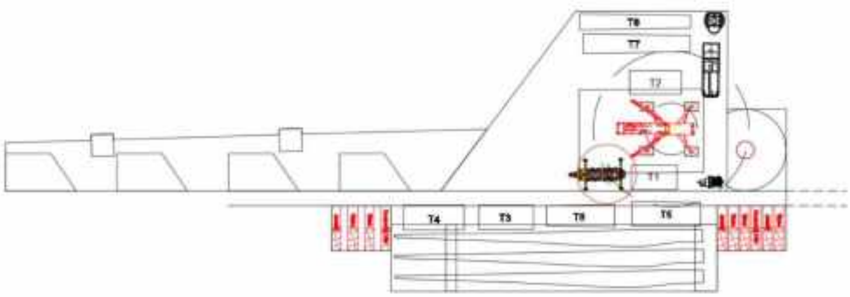


Figure 26 Model T155m – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard) – STD tower





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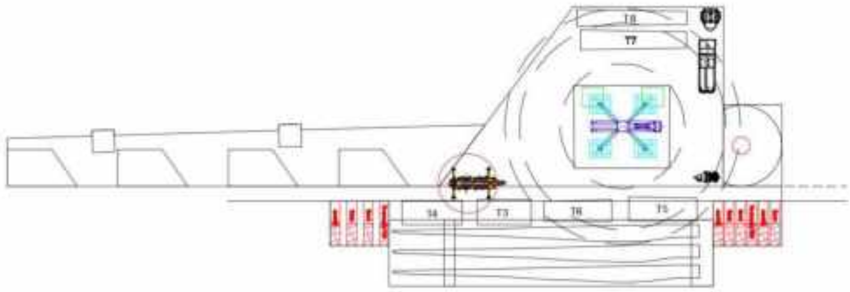

Figure 27 Model T155m - Partial storage assembling with strategy 4 in 2 phases

5.4.19. T165m MB - WT tubular steel tower Hardstand with strategy 3

The sizing of the hardstand corresponds to the use of a large wide track crawler crane and not the standard crane LG1750.

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 51m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 59m x 50m + (18m x 50m)/2 + 8m x 10m – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 51m x 22m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 53m x 42m + (14m x 42m)/2 + 8m x 10m – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

*Referred to 3.1.4 Road width

Table 24. Dimensions of the areas of model T165m MB – WT with strategy 3 – Tailing crane offloading

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- Total storage – Assembly in 1 phase

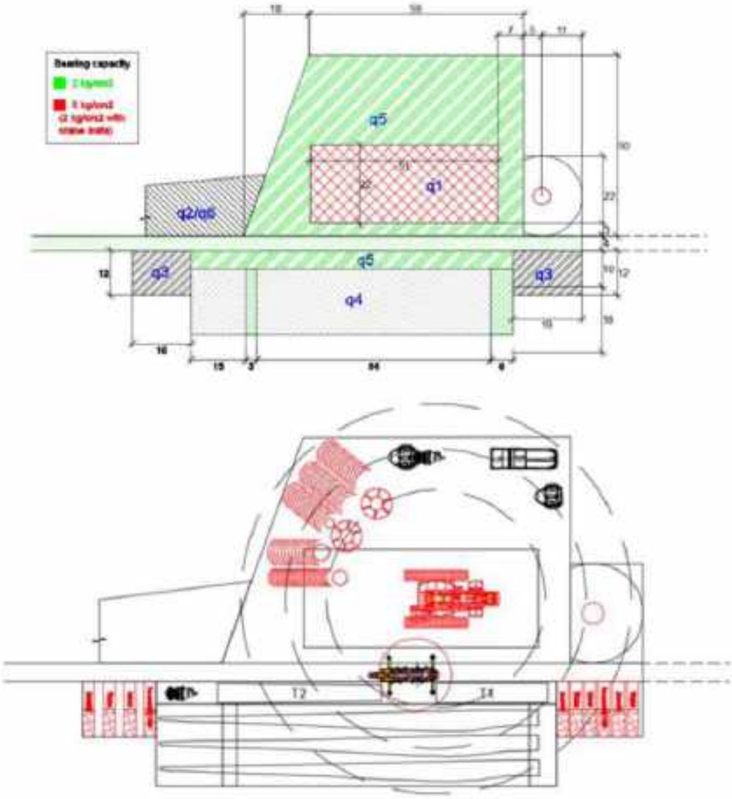
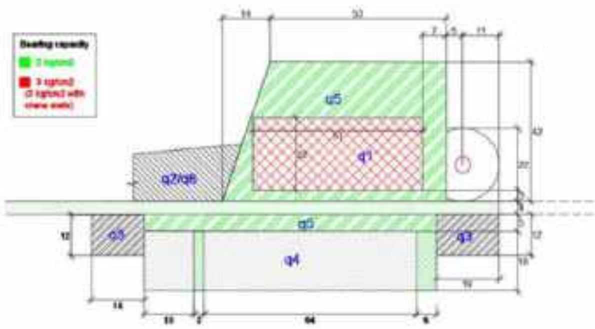


Figure 42. Model T165m MB – Total storage assembling with strategy 3 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



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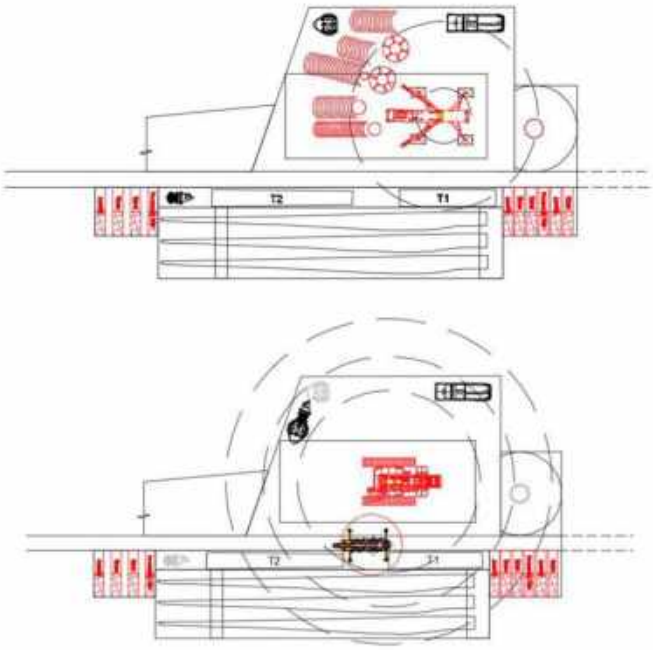

Figure 43. Model T165m MB – WT – Partial storage assembling with strategy 3 in 2 phases

5.4.20. T165m MB - WTtubular steel tower Hardstand with strategy 4

- Tailing crane offloading

Storage conditions	Width x length
Total Storage	q1: 33m x 28m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 70m x 50m + (25m x 50m)/2 + 8m x 10m - q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
Partial storage (SGRE standard)	q1: 33m x 28m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 51m x 50m + (29m x 50m)/2 + 8m x 10m – q1 + 88m x 5m + reinforced road part* q2/q6 : Dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 18. Dimensions of the areas of model T165m MB – WT with strategy 4 – Tailing crane offloading

*Referred to 3.1.4 Road width

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- Total storage – Assembly in 1phase

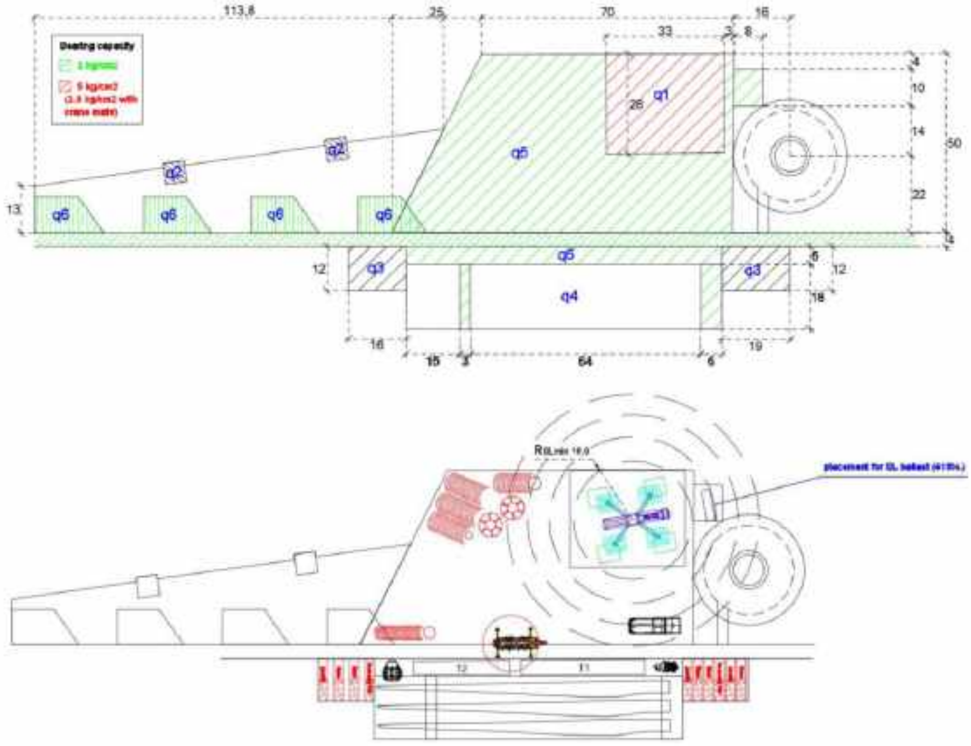
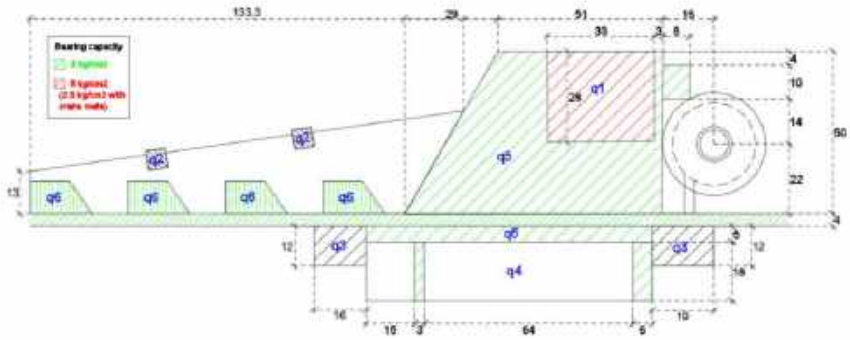


Figure 44. Model T165m MB – WT – Total storage assembling with strategy 4 in 1 phase

- Partial storage – Assembly in 2 phases (SGRE standard)



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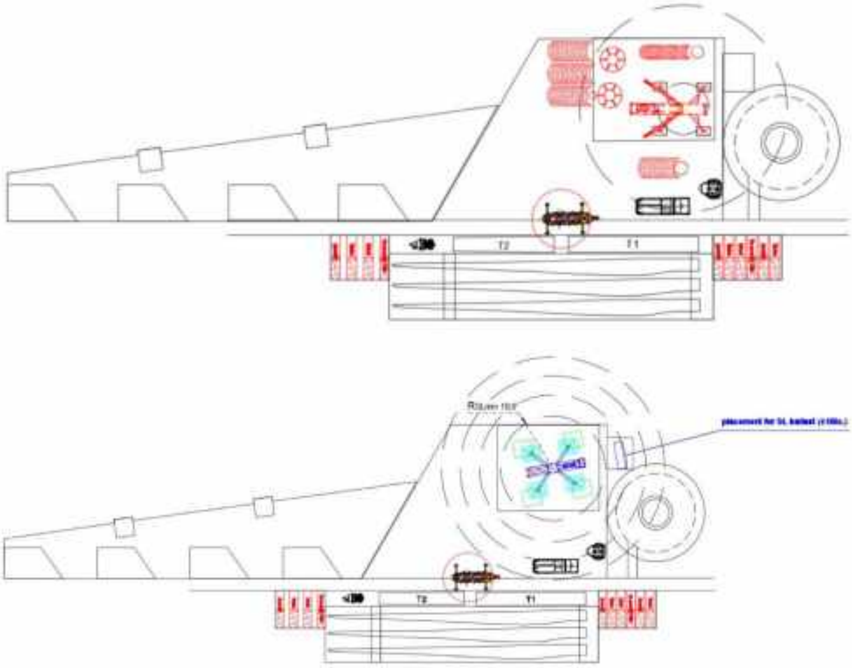

Figure 45. Model T165m MB – WT – Partial storage assembling with strategy 4 in 2 phases

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5.4.21. JIT storage tubular steel tower Hardstand with strategy 3

- Tailing crane offloading

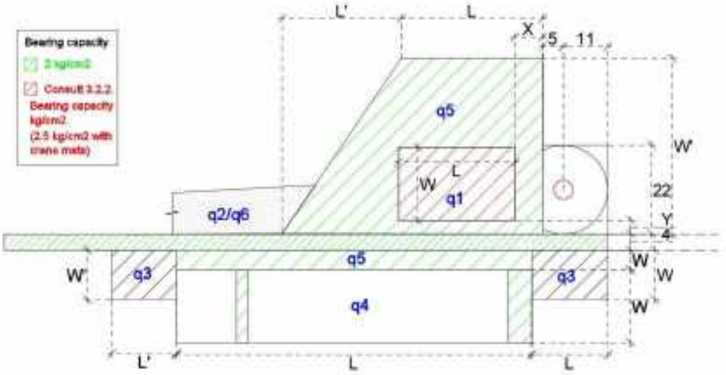
Storage conditions	HH	Width x length
JIT	100 110.5 115 135 **	q1: 29m x 18m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 35m x 44m + (30m x 44m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane
JIT	145 150 155	q1: 34m x 23m q3: 16m x 12m + 19m x 12m q4: 88m x 18m (with fingers of q5 hardstand 3m x 18m + 6m x 18m) q5: 35m x 44m + (30m x 44m)/2 – q1 + 88m x 5m + reinforced road part* q2/q6: Dimensions according to the 3.2.7. Requirements for assembly the main crane

Table 19. Dimensions of the areas of JIT storage – Tailing crane offloading

*Referred to 3.1.4 Road width

** The required dimensions for SE&A JIT hardstands tower height T115m and T135m can be found in document reference INS-62237 Site JIT hardstands in SE&A wind farms.

- Total storage – Assembly in 1 phase



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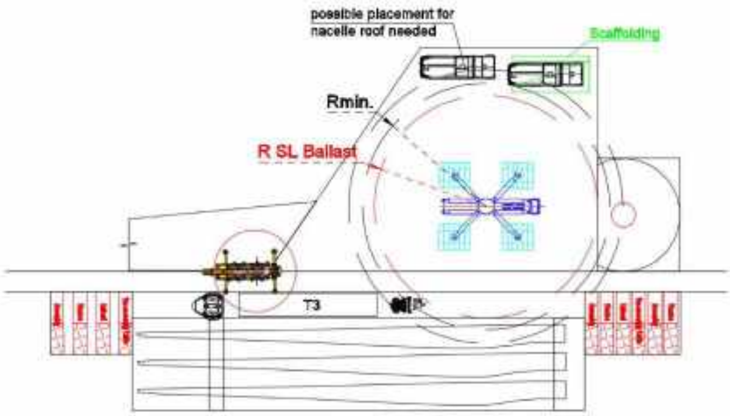

Figure 46. JIT storage reference hardstand

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2.3. CUMPLIMIENTO DELOS CODIGOS DE RED PARA CONEXIÓN DE PARQUES EÓLICOS

Documento de cumplimiento de los protocolos de conexión para los aerogeneradores SIEMENS GAMESA

GCODER_SPAIN_SG 5.X

Document ID and revision	Status	Status date (yyyy-mm-dd)	Language
GD468732 R3		2022-02-28	en-US

Original or translation of	RDS-PP®
Original	

File name
GD468732 R3.docx

Updates made since the previous revision
Added new grid code documentation (NTS V2.1 and BOE-A-2021-904), New Template, New Grid capability and certifications status. Syntax Update.

Confidentiality:	Deliverable Type	Doc Classification:
3 / CUSTOMER INFORMATION	S12 - General Characteristics Manual	STD - Support

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1. Aim

This document analyses the capabilities of Wind Turbine Generators (WTGs) developed by Siemens Gamesa Renewable Energy (SGRE) against the Grid Code requirements applicable **Spain** for the connection of Wind Farms (WF) to the **transmission and distribution** power grid. The main objective of this document is to provide a general overview of the compliance level of a WF with SGRE WTGs and SCADA/WF regulators.

2. Scope

The document considers **SG 5.X-170** platform together with the SCADA and WF regulator developed by SGRE.

It is important to note that most requirements are applicable at the Point of Common Coupling (PCC) of the WF and not directly at each of the WTGs' terminals. For this reason, the capabilities analysis is carried out with two different approaches depending on the requirement:

- ► Requirements for which WF compliance depends fundamentally on the WTG and/or SCADA/WF regulator capabilities (e.g. frequency operation range, fault ride through support, active power/frequency regulation…) → For these, an assessment of the WF compliance level is provided based on WTG and/or SCADA/WF regulator capabilities.
- ► Requirements for which the WTG and/or SCADA/WF regulator capabilities are only a factor for the WF compliance (e.g., voltage operation range, reactive power operation range, power quality…) → For these the WTG and/or SCADA/WF regulator capabilities to contribute to the WF compliance are provided.

The most appropriate converter configurations will be considered for the Grid Code analysis so that the requirements are fulfilled at the greatest possible extent but at the lowest cost. Considering the Grid Code analyzed in this document, the converters have been selected according Table 1 and their compliance with the Grid Code analyzed.

Platform	Converter
SG5.X-170	-

Table 1 Selected Converters.

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3. Acronyms, Definitions and Legend

Acronym	Description
AM	Application Mode
BOP	Balance of Plant
CCU	Converter Control Unit
DSO	Distribution System Operator, or the relevant governing body regarding grid connection requirements
EMT	Electromagnetic Transient
FSM	Frequency Sensitive Mode
GC	Grid Code
GCA	Grid Code Analysis
GE	Global Engineering
GE-GC	Global Engineering- Grid Connection
HV	High Voltage
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
PD	Product Development team
LFSM-O	Limited Frequency Sensitive Mode - Overfrequency
LFSM-U	Limited Frequency Sensitive Mode - Underfrequency
LV	Low Voltage
MV	Medium Voltage
N/A	Not Applicable
OLTC	On Load Tap Changer
OVRT	Overvoltage Ride Through
PCC	Point of Common Coupling
PD	Product Development (PD) team
PGM	Power Generating Module
PLC	Programmable Logic Controller
PSS	Power System Stabilizer
p.u.	Per Unit
RMS	Root-Mean-Square
ROCOF	Rate of Change of Frequency

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SCADA	Supervisory Control and Data Acquisition
SGRE	Siemens Gamesa Renewable Energy
SSCI	Sub-Synchronous Control Interactions
STATCOM	Static Synchronous Compensator, also known as SVG
TSO	Transmission System Operator, or the relevant governing body regarding grid connection requirements
UVRT	Undervoltage Ride Through
WF	Wind Farm
WFR	Wind Farm Regulator
WTG	Wind Turbine Generator

Table 2 Acronyms.

Definition	Description
$\cos \varphi$	Power factor
f_n	Nominal frequency
I_1	Positive Sequence Current
I_2	Negative Sequence Current
I_q	Reactive Current
I_r	Rated Current
P	Active Power
P_n	Nominal Active Power
Q	Reactive Power
Tamb	Rated Ambient Temperature
THD	Total Harmonic Distortion
U_n	Nominal Voltage

Table 3 Definitions.

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Legend	Description
Compliance	Compliance is expected
Development in Progress	A SCADA or WTG development is planned or underway in order to assure compliance
Request development upon need	A specific development is required and shall be requested when a project needs to comply with this requirement.
To be Clarified	The requirement is not clear, or information is missing. Therefore, it shall be clarified with the Operator.
Non-compliance	The requirement cannot be fulfilled.
Wind Farm Study Needed	Wind Farm Study Needed

Table 4 Legend.

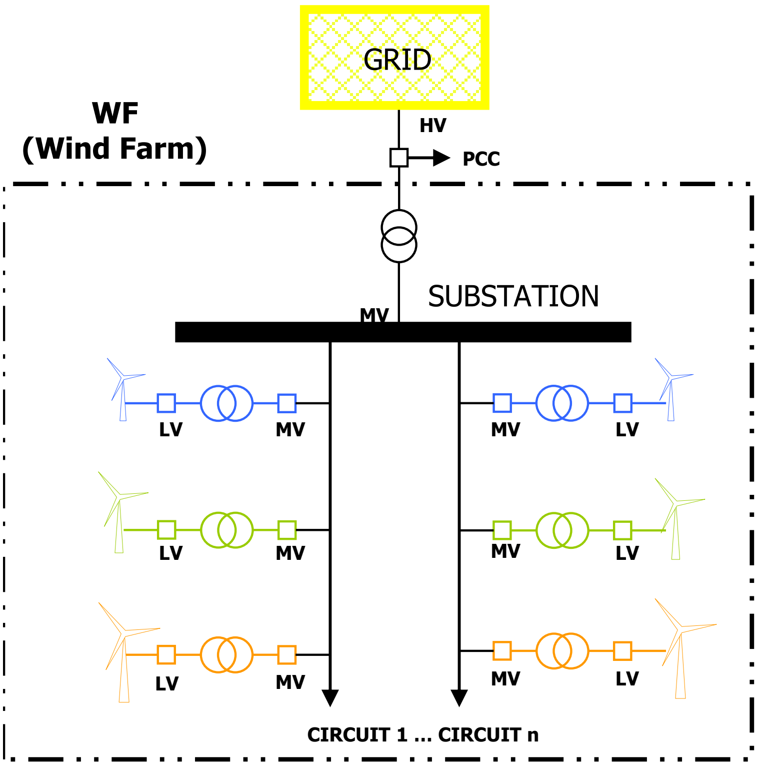

Figure 1 Conceptual scenario.

SIGN CONVENTION FOR REACTIVE POWER:

The following sign convention regarding reactive power is used for the whole analysis:

- Reactive power absorption: The WTG imports reactive power from the public power grid. This operation is equivalent to a coil/reactor or an underexcited synchronous generator.
- Reactive power supply: The WTG exports reactive power to the public power grid. This operation is equivalent to a capacitor or an overexcited synchronous generator.

The terms “inductive reactive power” and “capacitive reactive power” are intentionally omitted in order to avoid any confusion.

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4. Country Regulations Overview

The purpose of the analyzed document procedure is to establish minimum requirements for design, equipment, operation, commissioning and safety of the facilities connected to the Spanish mainland electrical system transport network, as well as the production and demand facilities in those aspects that they are applicable because of their influence on the electrical system as a whole, both from the Spanish mainland perspective and from the interconnected European system.

In this sense, the subject of the analyzed procedure is the establishment of the technical requirements and procedures established in the Commission Regulation (EU) 2016/631 of April 14, 2016, which establishes a network code on the connection requirements of generators to the network and complete the development of those requirements required by the Regulation; as well as technical aspects that, a priori, because of their local influence (not "cross-border") are outside the scope of European regulations but that have total relevance in the operation and safety of the electrical system.

The documents to be analyzed are:

- **BOE-A-2020-7439, "Real Decreto 647/2020, de 7 de julio, por el que se regulan aspectos necesarios para la implementación de los códigos de red de conexión de determinadas instalaciones eléctricas", 08/July/2020** [1]**.**
- **BOE-A-2020-8965, "Orden TED/749/2020, de 16 de julio, por la que se establecen los requisitos técnicos para la conexión a la red necesarios para la implementación de los códigos de red de conexión, 01/August/2020"** [2]**.**
- **"Reglamento (UE) 2016/631. Código de red sobre requisitos de conexión de generadores a la red", April/2016** [3]**.**
- **Norma técnica de supervisión de la conformidad de los módulos de generación de electricidad según el reglamento UE 2016/631, Revisión 2.1, 09/July/2021** [4]**.**
- **"P.O. 9 Información intercambiada por el operador del Sistema", 20/December/2019** [5]**.**
- **"Condiciones de Validacion y Aceptacion de los Modelos", Revision June/2020** [6]**.**
- **"Requisitos de los modelos de instalaciones eólicas, fotovoltaicas, de almacenamiento y de todas aquellas instalaciones que no utilicen generadores síncronos directamente conectados a la red", Revision June/2020** [7]**.**
- **"Requisitos de los modelos de instalaciones FACTS", Revision June/2020** [8]**.**
- **BOE-A-2021-904, "Circular 1/2021, metodología y condiciones del acceso y de la conexión a las redes de transporte y distribución de las instalaciones de producción de energía eléctrica** [9]**.**

Documents [1], [2], [3], [4] and [5] will be simply known as The Grid Code.

The requirements are specified depending on the type of the PGM (power-generating module) capacity and voltage level as specified in Item 1 of "Article 8 – Evaluación de la significatividad de los módulos de generación de electricidad" of the Grid Code [1]

a) Tipo A: módulos de generación de electricidad cuyo punto de conexión sea inferior a 110 kV y cuya capacidad máxima sea igual o superior a 0,8 kW e igual o inferior a 100 kW.
b) Tipo B: módulos de generación de electricidad cuyo punto de conexión sea inferior a 110 kV y cuya capacidad máxima sea superior a 100 kW e igual o inferior a 5 MW.
c) Tipo C: módulos de generación de electricidad cuyo punto de conexión sea inferior a 110 kV y cuya capacidad máxima sea superior a 5 MW e igual o inferior a 50 MW.
d) Tipo D: módulos de generación de electricidad cuyo punto de conexión sea igual o superior a 110 kV o cuya capacidad máxima sea superior a 50 MW.

For the Power Quality requirements, it is going to be considered the Annex I "Contenido de la base de datos estructural del operador del Sistema" of the document [5].

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5. Requirements Analysis

5.1. Rated Operation Range

5.1.1. Frequency Operation Range

- REQUIREMENTS:

The Grid Code requirements related with the Frequency Operation Range at rated voltage and power – and the allowed power deratings – can be found in section "Rangos de Frecuencia" of document [2].

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

	Item	Unit	Value
	Nominal Frequency	Hz	50
	Underfrequency		
1	Underfrequency Value 1	p.u.	0.95
	Underfrequency Time 1	s	1800
2	Underfrequency Value 2	p.u.	0.97
	Underfrequency Time 2	s	1800
3	Underfrequency Value 3	p.u.	0.97
	Underfrequency Time 3	s	continuous
4	Underfrequency Value 4	p.u.	0.97
	Underfrequency Time 4	s	continuous
5	Underfrequency Value 5	p.u.	0.97
	Underfrequency Time 5	s	continuous
	Overfrequency		
1	Overfrequency Value 1	p.u.	1.03
	Overfrequency Time 1	s	1800
2	Overfrequency Value 2	p.u.	1.02
	Overfrequency Time 2	s	1800
3	Overfrequency Value 3	p.u.	1.02
	Overfrequency Time 3	s	1800
4	Overfrequency Value 4	p.u.	1.02

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	Overfrequency Time 4	s	continuous
5	Overfrequency Value 5	p.u.	1.02
	Overfrequency Time 5	s	continuous
	ROCOF		
	ROCOF limit	Hz/s	2.0
	Applicable Time Frame for ROCOF	s	0.5

Table 5 Grid Code requirements for Frequency Operation Range at PCC.

- COMPLIANCE:

SG5.X-170:

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D3120497 [10]	✔ Compliance

WIND FARM:

The frequency operation requirements can be extrapolated from the PCC and be directly applied to the LV terminals of the WTGs. Therefore, the analysis performed for a SGRE platform can be considered equivalent to the compliance analysis of the WF at its PCC if the rest of the equipment at the WF level also withstands this frequency operation range.

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5.1.2. Voltage Operation Range

- REQUIREMENTS:

The Grid Code requirements related with the Voltage Operation Range can be found in section “REQUISITOS DE TENSIÓN DE LOS MÓDULOS DE GENERACIÓN DE ELECTRICIDAD” of document [2].

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

	Item	Unit	Value			
	Undervoltage		**Type B/C < 110kV Distribution (2)**	**Type B/C/D < 110kV Transmission (3)**	**Type D ≥ 110kV and < 300 kV Transmission (1)**	**Type D ≥ 300kV and ≤ 400 kV Transmission**
1	Undervoltage Value 1	p.u.	0.85	0.05	0.0	0.0
	Undervoltage Time 1	s	0	0.2	0.15	0.15
2	Undervoltage Value 2	p.u.	0.85	0.85	0.85	0.85
	Undervoltage Time 2	s	1.15	1.5	1.5	1.5
3	Undervoltage Value 3	p.u.	0.85	0.85	0.85	0.85
	Undervoltage Time 3	s	continuous	3600	3600	3600
4	Undervoltage Value 4	p.u.	0.85	0.85	0.9	0.9
	Undervoltage Time 4	s	continuous	continuous	3600	3600
5	Undervoltage Value 5	p.u.	0.85	0.85	0.9	0.9
	Undervoltage Time 5	s	continuous	continuous	continuous	continuous
	Overvoltage					
1	Overvoltage Value 1	p.u.	1.2	1.2	1.2	1.2
	Overvoltage Time 1	s	0	0	0	0.
2	Overvoltage Value 2	p.u.	1.15	1.2	1.2	1.2
	Overvoltage Time 2	s	0.5	0.05	0.05	0.05
3	Overvoltage Value 3	p.u.	1.15	1.15	1.15	1.1
	Overvoltage Time 3	s	1	1	1	1
4	Overvoltage Value 4	p.u.	1.1	1.15	1.15	1.1
	Overvoltage Time 4	s	1	3600	3600	3600

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5	Overvoltage Value 5	p.u.	1.1	1.118	1.118	1.0875
	Overvoltage Time 5	s	continuous	3600	3600	3600

Table 6 Grid Code requirements for Voltage Operation Range at PCC.

Remarks:

(1) For voltage operation compliance evaluation is used the worst profile, it is MGE Type D connected to the transmission grid with **≥110kV and < 300 kV**
(2) For WF types B / C connected to the Distribution system, the GC only defines one point for undervoltage condition (<0.85; 1.15 sec), 0.85 is assumed for continuous operation
(3) For WF types B / C connected to transmission system, the operating range is defined as the envelope of the UVRT curve and the continuous operating voltage table

- COMPLIANCE:

SG5.X-170:

According to the document D3120497 [10], the capability of SG5.X-170 to contribute to the WF compliance of the continuous operation voltage range at rated frequency and rated active power is the following:

Continuous Operation Voltage Range		Maximum Negative Sequence Voltage
Min	Max	
0.95Un	1.12Un	≤5%

Table 7 Continuous operation voltage range of SG5.X-170 at MV terminals.

In addition, they are capable of withstanding symmetrical and asymmetrical faults for any voltage profile within the curves illustrated in Figure 2 without disconnecting.

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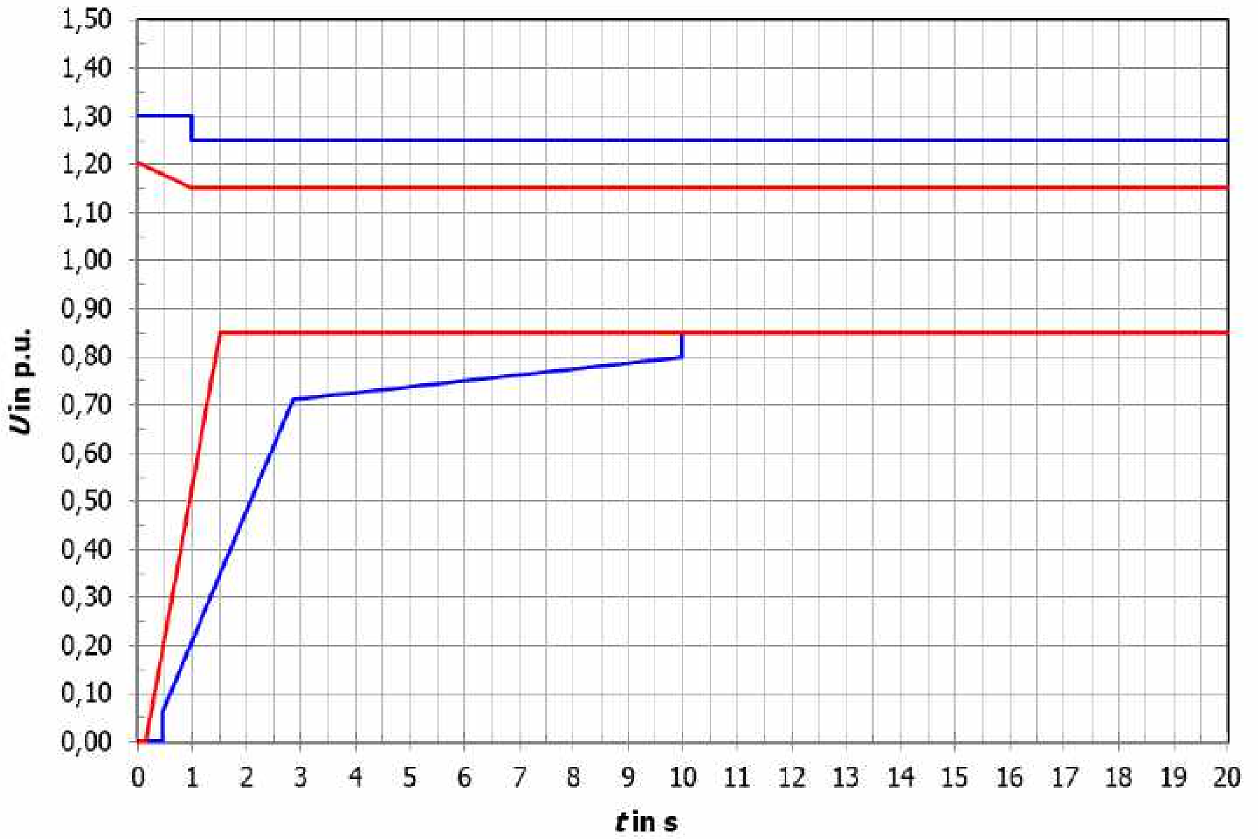

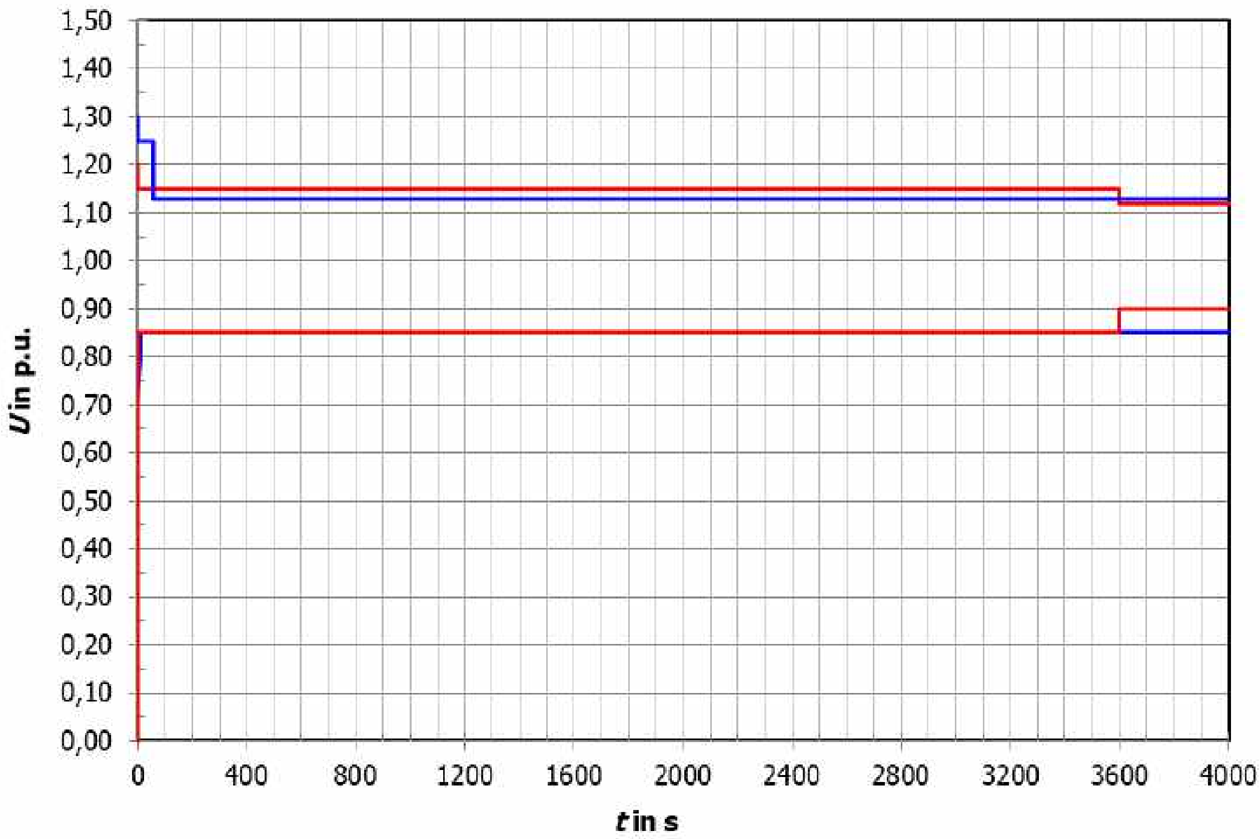

Figure 2. Voltage capability of SG5.X-170 at the **MV terminals** (blue) versus voltage profile required by the Grid Code at the PCC (red).

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WIND FARM:

The requirements regarding voltage operation range are specified at the PCC.

Considering this, to ensure compliance a specific study of the whole WF must be carried out in order to analyze the voltage operation range at the WTGs terminals for different operation scenarios of the WF. If this range can be for a certain time beyond the mentioned WTG limits, the WTGs may disconnect.

The complete WF electrical design must be taken into account for these studies, being the following the higher impact elements:

1. On-Load Tap Changer (OLTC): Substations transformers equipped with OLTC are able to decouple the voltage at the PCC with the voltage at the WF collector system.
2. WF collector system impedances: The voltage drop/rise at WTGs terminals across the WF collector system is dependent on this.
3. Reactive power control operation: The reactive power provided by WTGs and other reactive compensation elements causes voltage drop/rise at WTGs terminals. This control is done:
    - In continuous operation by the WF regulator, dispatching setpoints to the different elements.
    - In transient situations by the individual elements.

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5.1.3. Voltage/Frequency Operation Area

- REQUIREMENTS:

The Grid Code requirements related with the Voltage/ Frequency Operation Area can be found in section 1.1 "RANGOS DE FRECUENCIA" of document [2].

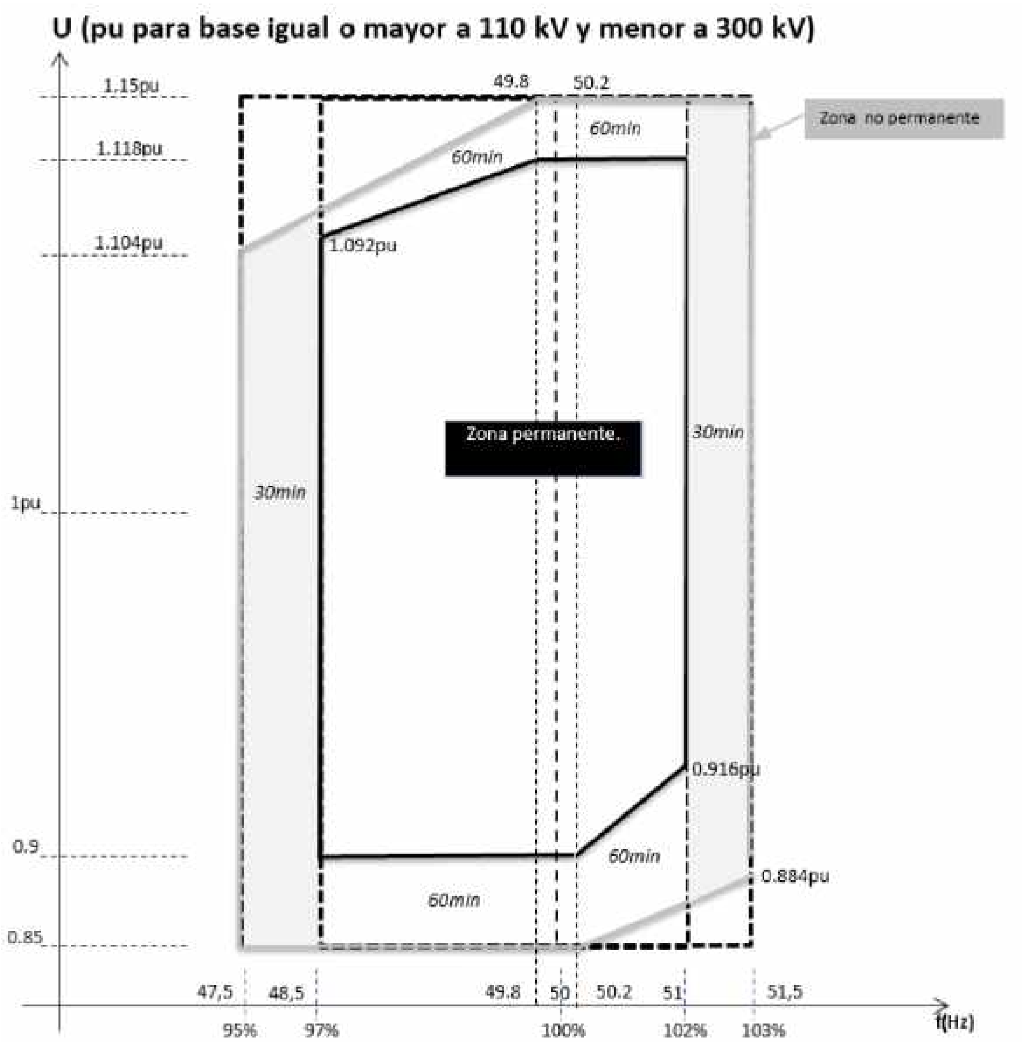

Figure 3. Voltage/Frequency requirements ≥ 110 to <300 kV.

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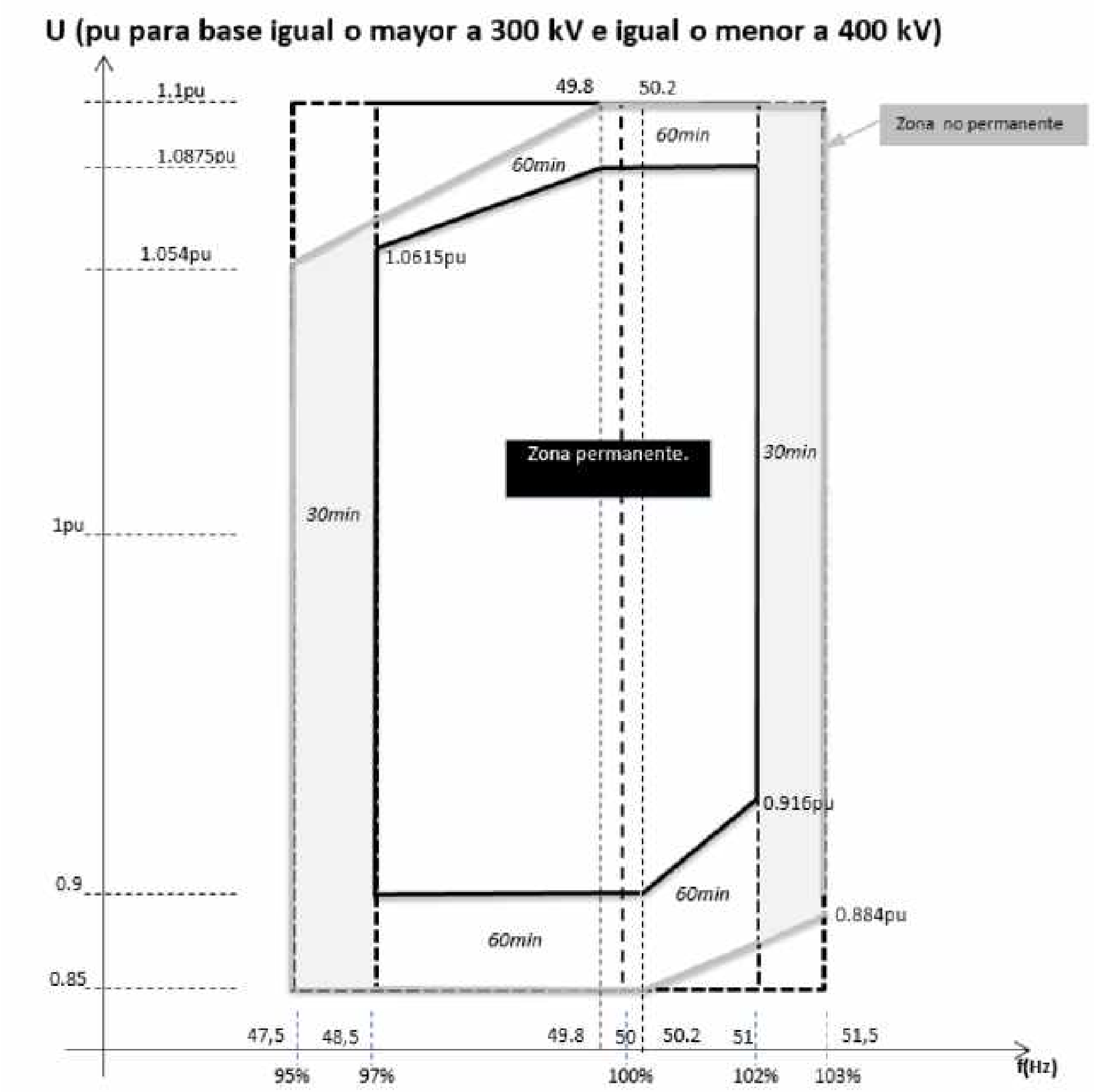

Figure 4. Voltage/Frequency requirements ≥ 300 to <400 kV.

- COMPLIANCE:

<u>SG5.X-170:</u>

The capability of SG5.X-170 WTGs to contribute to the WF compliance of this requirement can be found in D3120497 [10].

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WIND FARM:

The requirements regarding voltage/frequency operation range are normally specified at the PCC. Frequency requirements can be extrapolated from the PCC and be directly applied to LV terminals of the WTGs. However, voltage requirements cannot be directly extrapolated to the LV terminals of the WTGs.

Considering this, to ensure compliance a specific study of the whole WF must be carried out in order to analyze the voltage operation range at the WTGs terminals for different operation scenarios of the WF. If this range can be for a certain time beyond the mentioned WTG limits, the WTGs may disconnect.

The complete WF electrical design must be taken into account for these studies, being the following the higher impact elements:

1. On-Load Tap Changer (OLTC): Substations transformers equipped with OLTC are able to decouple the voltage at the PCC with the voltage at the WF collector system.
2. WF collector system impedances: The voltage drop/rise at WTGs terminals across the WF collector system is dependent on this.
3. Reactive power control operation: The reactive power provided by WTGs and other reactive compensation elements causes voltage drop/rise at WTGs terminals. This control is done:
    - In continuous operation by the WF regulator, dispatching setpoints to the different elements.
    - In transient situations by the individual elements.

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5.1.4. Reactive Power Operation Range

- REQUIREMENTS:

The Grid Code requirements related with the Reactive Power Operation Range can be found in section 2.3.2 “CAPACIDAD DE POTENCIA REACTIVA” of document [2]

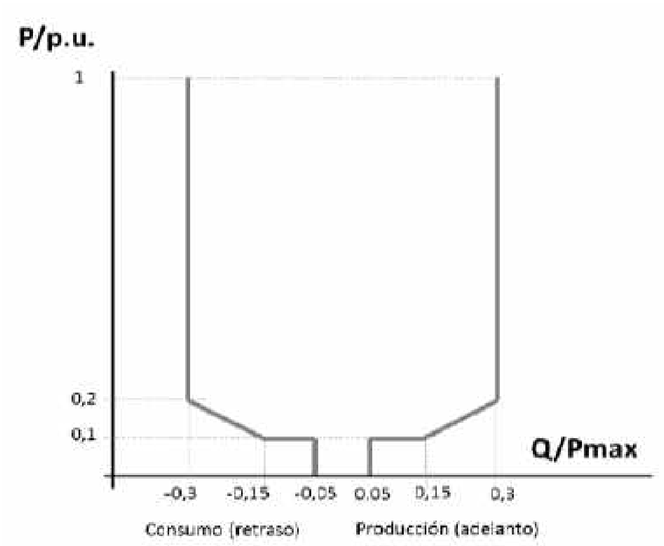

Figure 5. PQ requirements for MGE Type D

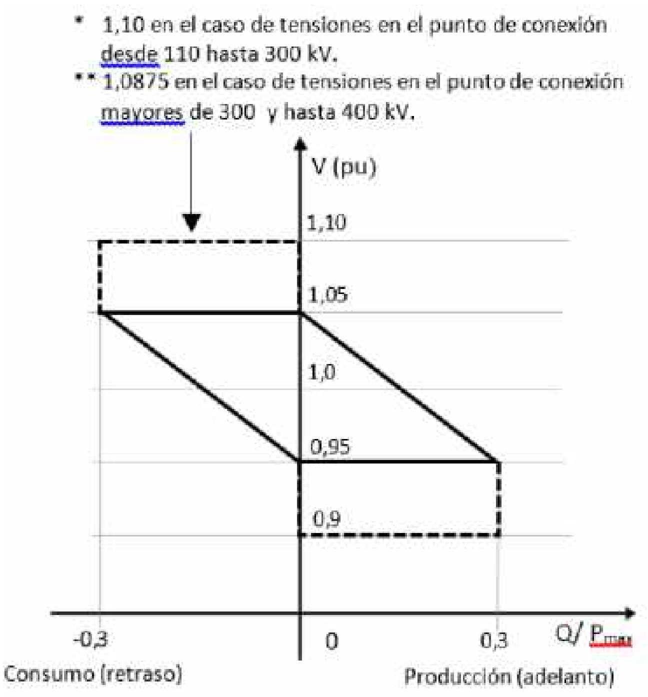

Figure 6. Q-U requirements for MGE Type D.

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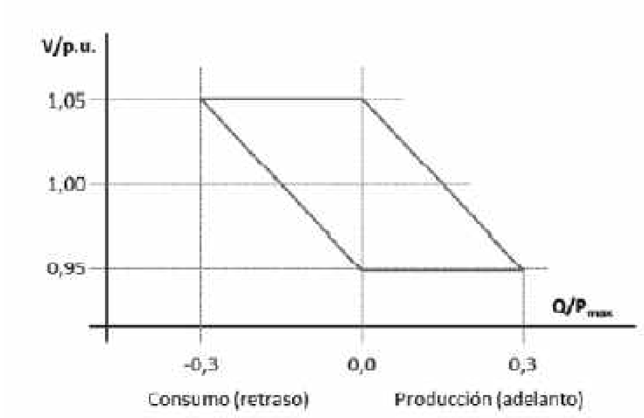

Figure 7. Q-U requirements for MGE Type B or C with Pmax<15MW.

There are particular Grid Code requirements related with the reactive power operation range when the central busbar of the MPE shares the facilities with other MPEs (Cases A and B) and it can be found in section 5.7.3.2 “Procedimiento específico en el caso de existencia de instalaciones compartidas” of document [4]

Case A

In the event that BC of the PGM is located at the HV side of the step-up transformer (LAT) of the PGM, the supplementary simulation shall be carried out considering both the voltage and the reactive power at BC (i.e. LAT in this case) in such a way that it will be necessary to model the collector network from the PGU up to BC, but not the evacuation network up to the NCP

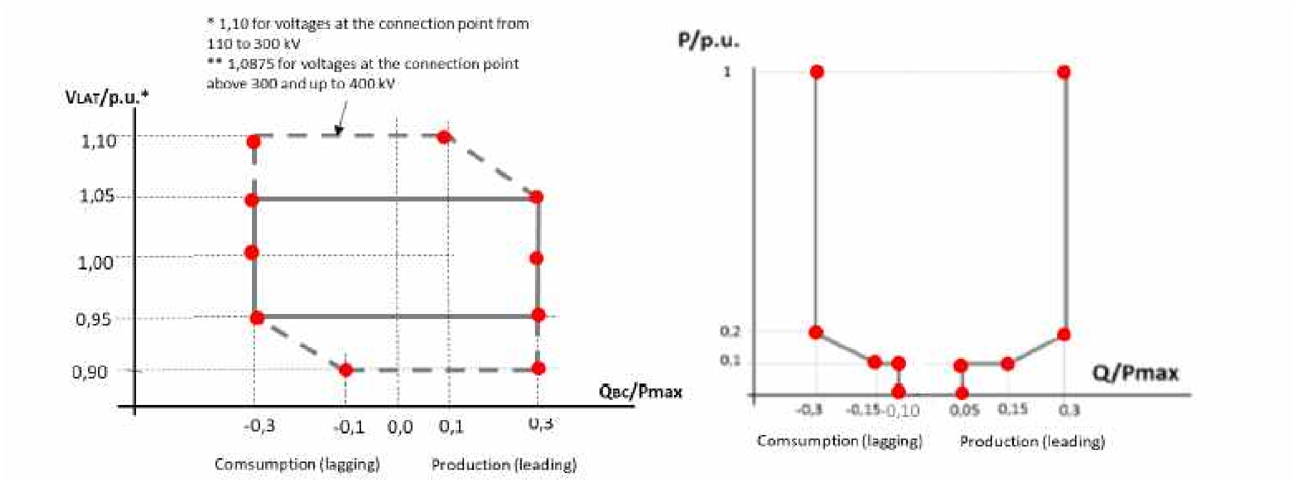

Figure 8. Q-U and PQ requirements for MGE Type D in special Case A

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Case B

If the BC of the PGM is located at the LV side of the PGM step-up transformer, the supplementary simulation shall be performed by measuring the reactive power at BC and considering the voltage at the HV side of the shared step-up transformer, so that it will be necessary to model the collector network from the PGU to BC and the shared transformer, but not the rest of the evacuation network up to the NCP

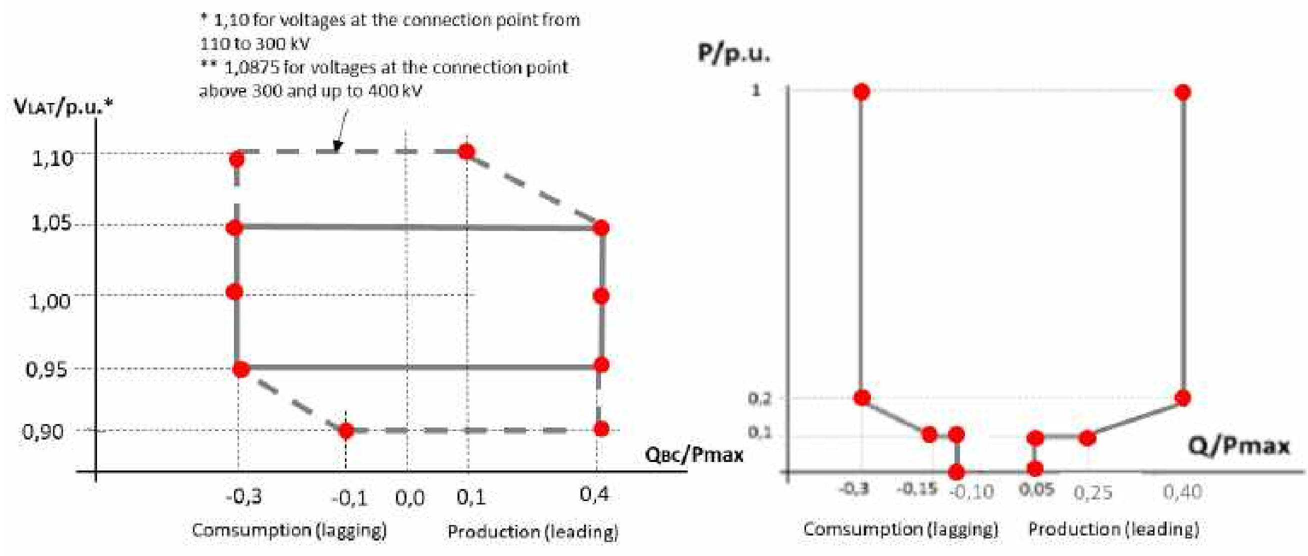

Figure 9. Q-U and PQ requirements for MGE Type D in special Case B

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Type D-C-B		Type Case A		Type Case B	
P (pu)	Q (pu)	P (pu)	Q (pu)	P (pu)	Q (pu)
0.00	-0.05	0	-0.10	0.00	-0.10
0.10	-0.05	0.10	-0.10	0.10	-0.10
0.10	-0.15	0.10	-0.15	0.10	-0.15
0.20	-0.3	0.20	-0.3	0.20	-0.3
1.00	-0.3	1.00	-0.3	1.00	-0.3
1.00	0.3	1.00	0.3	1.00	0.4
0.20	0.3	0.20	0.3	0.2	0.4
0.10	0.15	0.10	0.15	0.10	0.25
0.10	0.05	0.10	0.05	0.10	0.05
0.00	0.05	0.00	0.05	0.00	0.05

Table 8 Grid Code requirements for PQ capability at rated voltage.

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Type D ≥ 110 to <300 kV.		Type D ≥ 300 to <400 kV.		Type B / C with Pmax<15MW		Type Case A		Type Case B	
Q (pu)	V (pu)	Q (pu)	V (pu)	Q (pu)	V (pu)	Q (pu)	V (pu)	Q (pu)	V (pu)
0.00	0.95	0.00	0.95	0.00	0.95	0.00	0.9	0	0.9
-0.30	1.05	-0.30	1.05	-0.30	1.05	-0.1	0.9	-0.1	0.9
-0.30	1.10	-0.30	1.087	0.00	1.05	-0.3	0.95	-0.3	0.95
0.00	1.10	0.00	1.087	0.30	0.95	-0.3	1	-0.3	1
0.00	1.05	0.00	1.05	0.00	0.95	-0.3	1.05	-0.3	1.05
0.30	0.95	0.30	0.95			-0.3	1.10	-0.3	1.1
0.30	0.90	0.30	0.90			0.1	1.10	0.1	1.1
0.00	0.90	0.00	0.90			0.3	1	0.4	1.05
0.00	0.95	0.00	0.95			0.3	0.95	0.4	0.95
						0.3	0.9	0.4	0.9

Table 9 Grid Code requirements for QU capability at rated voltage.

- COMPLIANCE:

SG5.X-170:

The capability of SG5.X-170 WTGs to contribute to the WF compliance of this requirement can be found in the document D2904942 [11]

WIND FARM:

Considering that the reactive power requirements are specified at the PCC, an electrical study must be carried out by the WF developer in which both the power factor range at the PCC and the voltage deviations at the LV terminals of the WTGs are evaluated. This study would also determine if and to what extent compensation equipment is needed at the WF.

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5.2. Fault Ride Through Support

5.2.1. Current Support

- REQUIREMENTS:

The Grid Code requirements related with Fault Ride Through Current Support can be found in section "2.3 REQUISITOS DE TENSIÓN DE LOS MÓDULOS DE PARQUE ELÉCTRICO" of document [2] .

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

	Item	Unit	Value
	Current Support	-	Reactive & Active
	Current priority during VRT operation	-	Q priority
	Maximum Required Current Injection/Absorption	p.u.	1.00
	Current Injection/Absorption Calculation Mode	-	Relative Value
	Voltage Calculation Mode	-	Relative Value
	k Factor	-	2 ≤ K ≤ 6 by default = 3.50
	Response Time for Reactive Current Injection/Absorption		
	Tolerance band	+%/-%	-10% of In / +20% of In
	Reaction time	ms	≤ 40 (1)
	Rise time	ms	≤ 50
	Reaction time + Rise time	ms	≤ 50
	Response time	ms	-
	Settling time	ms	≤ 80 (1)
	Overshoot	%	-
	Reactive Current Absorption/Injection during UVRT/OVRT		
1	Voltage Setpoint 1 in p.u.	p.u.	1.30
1	Current Setpoint 1 in p.u.	p.u.	-1.05
2	Voltage Setpoint 2 in p.u.	p.u.	1.10
2	Current Setpoint 2 in p.u.	p.u.	-0.35
3	Voltage Setpoint 3 in p.u.	p.u.	1

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	Current Setpoint 3 in p.u.	p.u.	0
4	Voltage Setpoint 4 in p.u.	p.u.	0.9
	Current Setpoint 4 in p.u.	p.u.	0.35
5	Voltage Setpoint 5 in p.u.	p.u.	0.5
	Current Setpoint 5 in p.u.	p.u.	1.75
6	Voltage Setpoint 6 in p.u.	p.u.	0.00
	Current Setpoint 6 in p.u.	p.u.	3.50
	Controlled Asymmetrical Current Injection/Absorption	-	DFIG natural response

Table 10 Grid Code requirements for Current Support.

Remarks:

(1) With regard to the evaluation of these times, if for detecting UVRT condition was used current detection method, up to 20ms are added for the evaluation of these times, in order to determinate the rms value with average values of 20ms.

- COMPLIANCE:

<u>SG5.X-170:</u>

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D3120497 [10]	✔ Compliance

<u>WIND FARM:</u>

Usually compliance with this requirement is accepted to be evaluated at WTG terminals. Otherwise, if compliance is demanded at PCC, the WF developer must carry out studies in order to analyze the reactive current support achieved by the WF at the PCC and determine what extra equipment for reactive current support is necessary. Nevertheless, SGRE will cooperate with the WF developer in order to find the correct solution.

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5.2.2. Active Power Recovery After Clearance

- REQUIREMENTS:

The Grid Code requirements related with the Active Power Recovery After Clearance can be found in section 3.3 “REQUISITOS DE ROBUSTEZ DE LOS MÓDULOS DE PARQUE ELÉCTRICO” of document [2] and the section 5.11.2.5 “CRITERIOS DE EVALUACIÓN DEL REQUISITO DE RECUPERACIÓN DE LA POTENCIA ACTIVA TRAS EL HUECO DE TENSIÓN” of document [4]

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Active Power Level for Recovery Acceptance	%	95.0
Maximum Time for Active Power Recovery	s	1 s for Udip ≥ 0.5Un 2 s for 0.5Un > Udip ≤ 0.2Un 3 s for Udip < 0.2Un
Active Power Recovery Rate after UVRT Mode	pu/s	N/A
Active Power tolerance for settling acceptance	%	5
Maximum time for active power settling	s	3 s for Udip ≥ 0.5Un 4 s for 0.5Un > Udip ≤ 0.2Un 5 s for Udip < 0.2Un
Voltage level for active power recovery	pu	0.85

Table 11 Grid Code requirements for Active Power Recovery After Clearance.

- COMPLIANCE:

<u>SG5.X-170:</u>

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D3120497 [10]	✔ Compliance

<u>WIND FARM:</u>

Usually compliance with this requirement is accepted to be evaluated at WTG terminals. Otherwise, if compliance is demanded at PCC, the WF developer must carry out studies in order to analyze the active power recovery achieved by the WF at the PCC and determine what extra equipment for active power support is necessary. Nevertheless, SGRE will cooperate with the WF developer in order to find the correct solution.

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5.2.3. Consecutive Voltage Dips

- REQUIREMENTS:

The Grid Code requirements related with the Consecutive Voltage Dips can be found in section 2.3 “REQUISITOS DE TENSIÓN DE LOS MÓDULOS DE PARQUE ELÉCTRICO” of document [2]

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Time between Consecutive UVRTs	s	5
Number of Consecutive UVRTs	-	Not defined by GC
Time between series of consecutive UVRTs	s	N/A
Voltage level between consecutive voltage dips	%	Not defined by GC
Energy to be dissipated	Pn*s	WTG capability

Table 12 Grid Code requirements for Consecutive Voltage Dips.

- COMPLIANCE:

<u>SG5.X-170:</u>

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X	D3120497 [10]	✔ Compliance

<u>WIND FARM:</u>

Usually compliance with this requirement is accepted to be evaluated at each individual element of the WF.

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5.3. Active Power / Frequency Regulation

- REQUIREMENTS:

The Grid Code requirements related with **Active Power Regulation** can be found in section “1.6. Capacidad y rango de control de la potencia activa” of the document [2].

The Grid Code requirements related with **Frequency Regulation** can be found in section “1. REQUISITOS DE FRECUENCIA” of the d document [2].

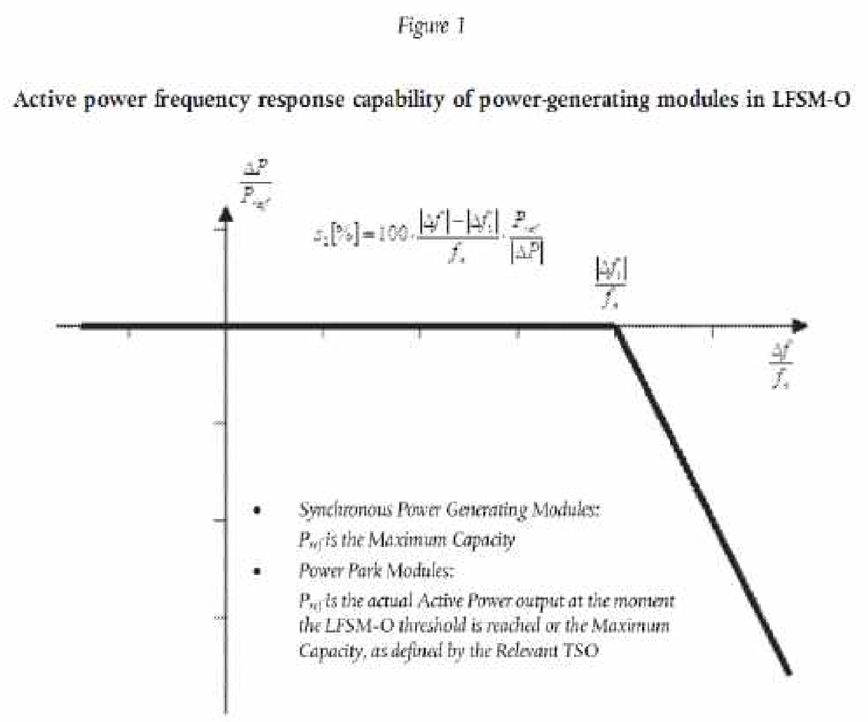

Figure 10 LFSM-O mode [3].

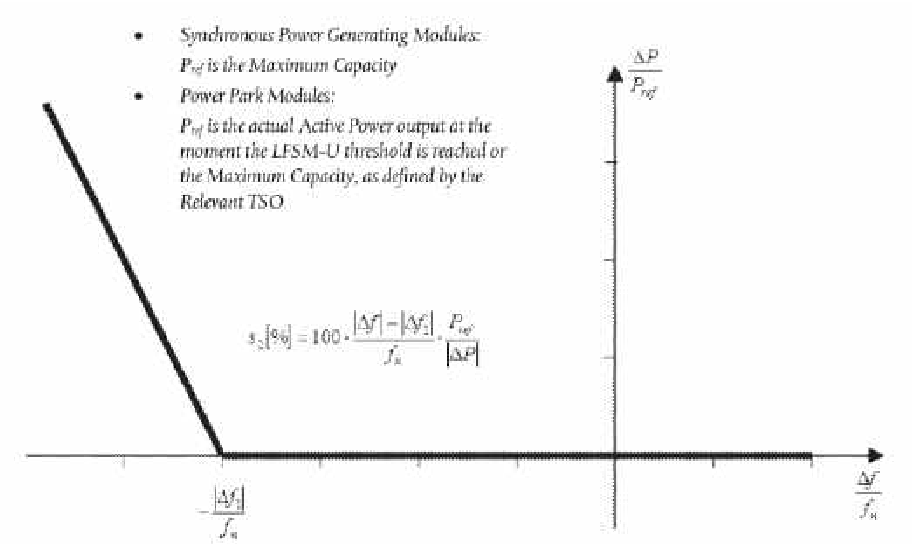

Figure 11 LFSM-U mode [3].

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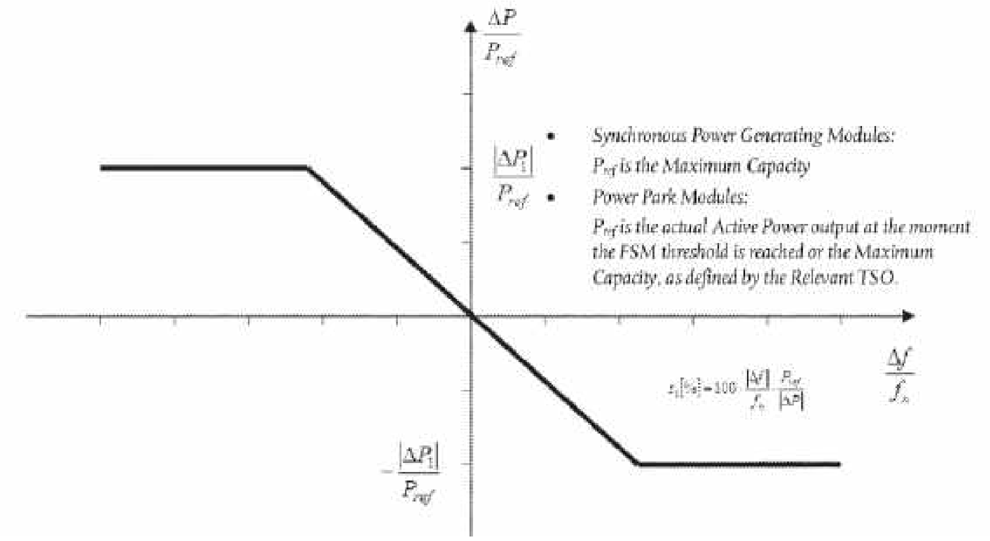

Figure 12 FSM mode [3].

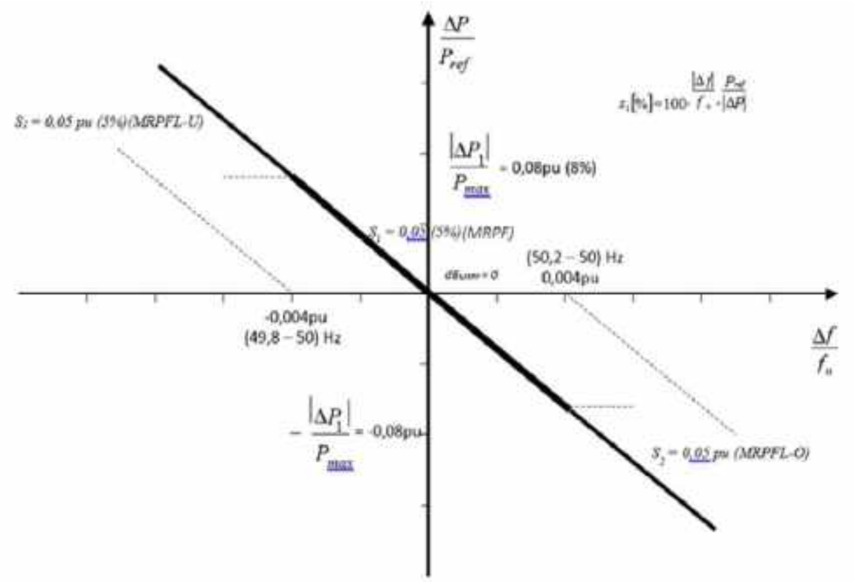

Figure 13 Example of the three modes combined [2].

The Grid Code requirements related with **Active Power Ramp Rates** can be found in section “5.9. Limitación a las rampas de subida y bajada de la potencia” of the document [2].

The Grid Code definition of the **Active Power Regulation Times** can be found in section “1.3” of the document [2]. The SGRE definition of the regulation times is included in the figure below. Note that this SGRE definition matches with the GC.

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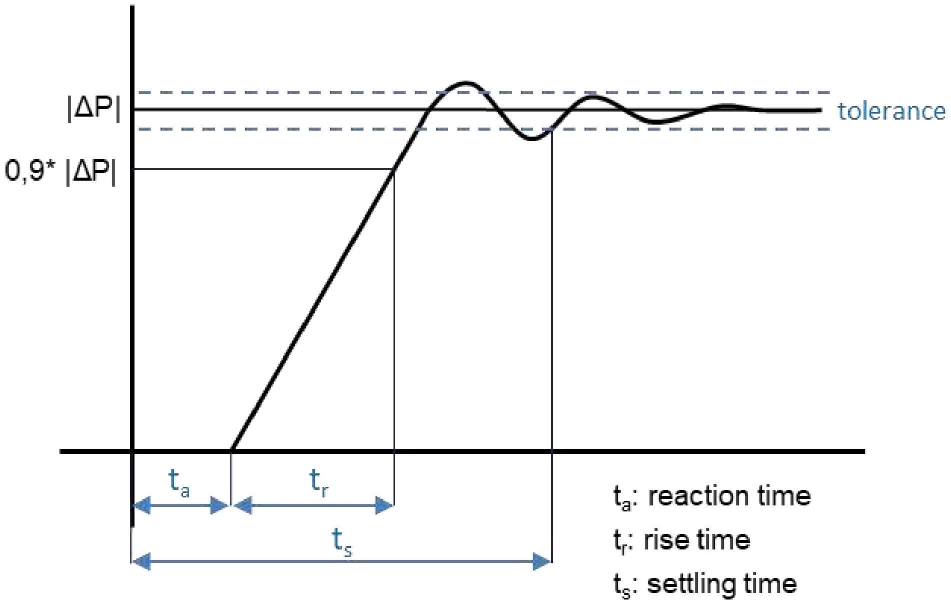

Figure 14 SGRE Definition of the regulation times: ta, tr and ts (te).

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Requirement Category	[Doc] Section	MODE / Requirement	Type B	Type C	Type D	Compliance
WF Types		Generator Type thresholds	Pn ≤ 5 MW and Vn < 110 Kv	Pn ≤ 50 MW and Vn < 110 Kv	Pn >50 MW or Vn ≥ 110 Kv	
ACTIVE POWER REGULATION		AVAILABLE POWER MODE	Not indicated in GC	Not indicated in GC	Not indicated in GC	✔ Compliance
		SPINNING RESERVE / DELTA CONTROL	Not indicated in GC	Not indicated in GC	Not indicated in GC	
	1.6 [2]	CURTAILMENT MODE	Required	Required	Required	✔ Compliance
	5.9 [4]	Curtailment Ramps	-	To be agreed with SO	To be agreed with SO	
	1.6 [2]	Curtailment settling time	Max 3 min	Max 2 min	Max 2 min	
	1.6 [2]	Curtailment Steady state tolerance	±5%Pn	±5%Pn	±5%Pn	
	OTHER:					
		CEASE POWER 5s Required	NA	NA	? To be Clarified (1)	
	1.3, 1.7, 1.8 [2]	FREQUENCY MODE	Required	Required	Required	✔ Compliance

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FREQUENCY REGULATION				Frequency Regulation at WTG level	No	No	No	
	1.3, 1.7, 1.8 [2]		ta/tr/ts (ramp down)	≤2s/≤2s/≤20s	≤500ms/ ≤2s/≤20s	≤500ms/ ≤2s/≤20s	To be Clarified (2)	
	1.3, 1.7, 1.8 [2]		ta/tr/ts (ramp up)	≤2s/≤5s/≤30s	≤500ms/ ≤5s/≤30s	≤500ms/ ≤5s/≤30s	To be Clarified (2)	
	1.3, 1.7, 1.8 [2]		Steady state tolerance freq. regulation	±5%ΔP	±5%ΔP	±5%ΔP	(3)	
	1.8 [2]	Secondary Frequency regulation	??	??	??	To be Clarified (4)		
	5.4 [4]	Frequency Restoration	??	??	??	To be Clarified (5)		
	-	Enhanced Frequency Ramps needed		Yes	Yes	Yes	To be Clarified (2)	
	OTHER:							

Table 13 Grid Code requirements for Active Power / Frequency Regulation.

Remarks:

(1) A steady state tolerance expressed as % of ΔP could imply a very demanding band for low power increase values. Therefore, ideally the tolerance shall be expressed as % of the rated power.
(2) Read aspects to clarify section 6.1 in this GCA.
(3) Read aspects to clarify section 0 in this GCA

According to the SGRE interpretation of the GC, the key frequency regulation parameters are summarized in the following table:

Mode	[Doc] Section	Parameter	Type B	Type C	Type D
LFSM-O	1.3 [2]	LFSM-O frequency threshold	50,2 Hz	50,2 Hz	50,2 Hz
	1.3 [2]	LFSM-O Droop setting	5%	5%	5%
	5.1 [4]	LFSM-O definition of Pref	Pnom	Pnom	Pnom
		Behavior of the PGM once the regulating minimum level is reached	Not defined	Not defined	Not defined

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LFSM - U	1.7 [2]	LFSM-U frequency threshold	NA	49.8 Hz	49.8 Hz
	1.7 [2]	Droop setting	NA	5%	5%
	5.2 [4]	LFSM-U definition of Pref	NA	Pnom	Pnom
FSM	1.8 [2]	|ΔP|/Pref	NA	8%	8%
	1.8 [2]	frequency response insensitivity	NA	= 10 mHz	= 10 mHz
	1.8 [2]	FSM deadband	NA	0 mHz	0 mHz
	1.8 [2]	FSM droop (up)	NA	5%	5%
	1.8 [2]	FSM droop (down)	NA	5%	5%
	5.3 [4]	FSM definition of Pref	NA	Pnom	Pnom
	1.8 [2]	t1 maximum admissible initial delay for PGMs without inertia	NA	500 ms	500 ms
	1.8 [2]	t2 maximum admissible full activation time	NA	30 s	30 s
	1.8 [2]	time period for the provision of full active power frequency response	NA	15 min	15 min

Table 14 Grid Code requirements for Regulation Parameters.

- COMPLIANCE:

SG5.X-170:

According to the document D3120497 [10], SG5.X-170 WTGs could comply with the required active power ramp rates.

Time responses required in frequency regulation (tr) makes that fast frequency ramps are required in order to provide fast frequency regulation active power ramps (22.5%Pn/s when decreasing power and 3.6%Pn/s when increasing power). SGRE SG5.X-170 could comply with this requirement but SW logics are pending to implement in serial SW

WIND FARM:

SGRE PPC cannot comply with all the requirements. The requirements related with the MRPF highlighted in section 6.1 of this GCA and the references to Frequency restoration in section 0 must be clarified.

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5.4. Reactive Power / Voltage Regulation

- REQUIREMENTS:

The Grid Code requirements related with the Reactive Power/Voltage Regulation can be found in section "2.3.3 Modos de control de potencia reactiva" of the document [2].

Additional requirements about reactive power regulation time response times found in the following section "2.3.2.1. Módulos de parque eléctrico tipo D" of document [2].

The SGRE definition of the regulation times is included in the figure below. Note that this SGRE definition does not match with the GC. Therefore, the GC regulation times have been adapted to SGRE definition in this GCA.

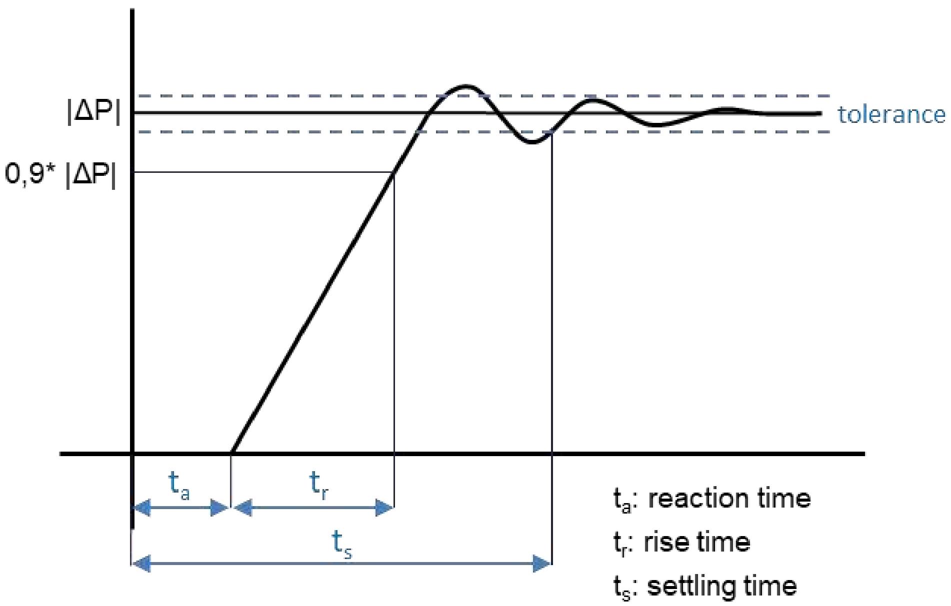

Figure 15 SGRE Definition of the regulation times: ta, tr and ts (te).

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Requirement Category	[Doc] Section	MODE / Requirement	Type B	Type C	Type D	Compliance
WF Types		Generator Type thresholds	Pn ≤ 5 MW and Vn < 110 Kv	Pn ≤ 50 MW and Vn < 110 Kv	Pn >50 MW or Vn ≥ 110 Kv	
	21.3.d.i [3]	5.2 COSPHI MODE (POWER FACTOR)	Required	Required	Required	✔ Compliance (1)
	5.8.2.3 [4]	(COSPHI) ta/tr/ts	…/…/60s	…/…/60s	…/…/60s	
	5.8.2.3 [4]	(COSPHI) Steady state tolerance	Q= ±1.5%Pmax	Q= ±1.5%Pmax	Q= ±1.5%Pmax	

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	21.3.d.i [3]	5.3 REACTIVE POWER MODE (Q)	Required	Required	Required	✔ Compliance (1)
	5.8.2.3 [4]	(MODE Q) ta/tr/ts	…/…/60s	…/…/60s	…/…/60s	
	5.8.2.3 [4]	(MODE Q) Steady state tolerance	Q= ±1.5%Pmax	Q= ±1.5%Pmax	Q= ±1.5%Pmax	
		5.4 DIRECT VOLTAGE MODE (V)	NA	NA	NA	
	2.3.3 [2]	5.5 REACTIVE POWER / VOLTAGE MODE (Q/V)	Required	Required	Required	✔ Compliance (1)
	2.3.3 [2]	(Q/V) curve defined by slope	Required	Required	Required	
	2.3.3 [2]	(Q/V) ta/tr/ts	ta+tr=1s ts= 5s	ta+tr=1s ts= 5s	ta+tr=1s ts= 5s	(2)
		AVAILABLE REACTIVE POWER AT PCC CALCULATION	NA	NA	NA	
	OTHER:					

Table 15 Grid Code Requirements for Reactive Power / Voltage Regulation.

Remarks:

(1) It must be agreed with client/SO the mode of operation of the reactive power/voltage control and its final parameter settings.

According to the SGRE interpretation of the GC, the key voltage regulation parameters are summarized in the following table:

Mode	[Doc] Section	Parameter	Type B	Type C	Type D
Q/V curve defined by slope		Slope (droop)	2%	2%	2%
		Slope resolution	Not defined	Not defined	Not defined
		Deadband	0 p.u.	0 p.u.	0 p.u.
		Deadband resolution	Not defined	Not defined	Not defined

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		Vmin/Vn	Not defined	Not defined	Not defined
		Vmax/Vn	Not defined	Not defined	Not defined
		Qmin	Not defined	Not defined	Not defined
		Qmax	Not defined	Not defined	Not defined
Q/V curve defined by points		[Q_1; P_1]	NA	NA	NA
		[Q_2; P_2]	NA	NA	NA
		[Q_3; P_3]	NA	NA	NA
		[Q_4; P_4]	NA	NA	NA
		[Q_5; P_5]	NA	NA	NA

Table 16 Grid Code requirements for Regulation Parameters.

- COMPLIANCE:

SG5.X-170:

According to the document D3120497 [10], SG5.X-170 WTGs can comply with the required reactive power ramp rates.

WIND FARM:

SGRE PPC can comply with all the requirements.

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5.5. Power Quality

- REQUIREMENTS:

No specific requirements for power quality have been found in the main document of the Grid Code [2]. It is important to highlight that even there is not a requirement in the Grid Code, SGRE will expect that the TSO will ask for some power quality measurements, such as asked in the Annex I “Contenido de la base de datos estructural del operador del Sistema” of the document “P.O. 9 Información intercambiada por el operador del Sistema” [5]

Remarks:

The GC requires voltage harmonic measures. These measures are outside of IEC 61000-21 scope. Therefore, it needs to consider voltage harmonic measures and current harmonic measures and should be to consider into account in the offer

- COMPLIANCE:

The WF developer may perform a power quality study to gain some certainty on the WF fulfilment of these requirements, and SGRE can provide WTG power quality reports or harmonic models for this purpose, but the recommendation is to only evaluate this once real WF measurements are available so effective solutions can be properly designed.

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5.6. Communications

- REQUIREMENTS:

The Grid Code requirements related with the Communications can be found in section "5.1 Intercambio de información" of the document [2]

"5.1 Intercambio de información.

Para los módulos de generación de electricidad de tipo A, B, C o D será de aplicación lo recogido en el procedimiento de operación que regule la información intercambiada por el operador del sistema y, en todo caso, en la normativa que al respecto sea aprobada para el intercambio de información con los gestores de la red."

More signal requirements regarding MRPF mode can be found on section "1.8. Modo de regulación potencia-frecuencia (MRPF)" of the document [2].

"Adicionalmente a lo especificado en cuanto a la monitorización en tiempo real del MRPF en el Reglamento (UE) 2016/631, de 14 de abril de 2016, el módulo de generación de electricidad estará capacitado para recibir en tiempo real del operador del sistema e implementar consignas de potencia en reserva a subir y a bajar mínimas garantizadas, que podrían ser diferentes. En el caso de módulos de parque eléctrico, las consignas de banda a subir y bajar se respetarán en la cuantía que permita la diferencia entre el recurso primario disponible y el nivel mínimo de regulación."

In addition, the RfG 2016/631 [3] stablishes for the MRPF mode the below requirements, as it's indicated in the paragraph above:

"Section 15.2 g) [Applies to MPE. Type C and Type D]

En cuanto a la monitorización en tiempo real del MRPF:

i) para monitorizar el funcionamiento de la respuesta frecuencia-potencia, la interfaz de comunicación deberá estar equipada para transferir en tiempo real y de forma segura desde la instalación de generación de electricidad hasta el centro de control de la red del gestor de red pertinente o del GRT pertinente, a instancias del gestor de red pertinente o del GRT pertinente, al menos las señales siguientes:

señal de estado del MRPF (activado/desactivado);
salida de potencia activa programada;
valor efectivo de la salida de potencia activa;
ajuste efectivo de los parámetros de respuesta de la potencia activa con la variación de frecuencia;
estatismo y banda muerta;

ii) el gestor de red pertinente y el GRT pertinente deberán especificar las señales adicionales que deberá proporcionar la instalación de generación de electricidad por los dispositivos de monitorización y registro con el fin de verificar el funcionamiento del suministro de reservas de regulación frecuencia-potencia por parte de los módulos de generación de electricidad participantes."

Requirement Category	[Doc] Section	MODE / Requirement	Type B	Type C	Type D	Compliance

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WF Types		Generator Type thresholds	Pn ≤ 5 MW and Vn < 110 Kv	Pn ≤ 50 MW and Vn < 110 Kv	Pn >50 MW or Vn ≥ 110 Kv	
COMMUNICATIONS		Hardwired signals required	Not defined	Not defined	Not defined	? To be Clarified (1)
		Signal list defined in the GC	Not defined	Not defined	Not defined	? To be Clarified (1)
		External communication protocols defined in the GC for SGRE SCADA	Not defined	Not defined	Not defined	? To be Clarified (1)

Remarks:

(1) The signal types and the communication protocols are not defined, so the project's specific signal list and communications architecture must be negotiated with the TSO and WF developer during the connection conditions agreement.

- COMPLIANCE:

WIND FARM:

SGRE CSSS/PPC has different communications protocols, installed and tested, to access third party data, such as the substation or the weather mast, and/or to permit third parties to access wind farm data without requiring additional development. These protocols are mainly OPC-UA, and IEC 60870-5-104.

The following topics must be considered:

- Communication with the System Operator will have to be performed by the Wind Farm Developer through a Substation RTU. The SGRE SCADA system can communicate with the RTU installed in the substation by using one of the protocols mentioned above (preferably IEC 60870-5-104 protocol).
- Signals of the substation devices, such as transformer taps, switchgears, connection breakers, etc. can be integrated in the SGRE SCADA system provided. These are included in the substation integration through the RTU by using IEC 60870-5-104 protocol.
- Signals referred to the WTGs can be provided by the SGRE SCADA system to the Substation RTU by using IEC 60870-5-104 protocol.
- The installation of a met mast should be considered by the WF developer. The signals of the met mast can be integrated in the SGRE SCADA system. The communication protocol for this has not been defined at the time of preparation of this document.

Anyway, the final signal types and the communication protocols are not defined, so the project's specific signal list and communications architecture must be negotiated with the TSO/DSO and WF developer during the connection conditions agreement.

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5.7. Protections

- REQUIREMENTS:

The Grid Code requirements related with the Protections can be found in Annex I “Contenido de la base de datos estructural del operador del Sistema” of the document “P.O. 9 Información intercambiada por el operador del Sistema” of the document [5]

“1.2.5.2 Protecciones asociadas a cada unidad generadora (aerogenerador, inversor, etc.).

• Relé de mínima tensión: indicar fases en que mide y ajustes.

• Relé de sobretensión: ajustes.

• Protección de mínima frecuencia: ajustes y cumplimiento del procedimiento por el que se establecen los Planes de Seguridad.

• Protección de sobrefrecuencia. Ajustes.

• Dispositivos automáticos de reposición por frecuencia: Confirmar que no existen o que están deshabilitados.

• Disparo por sobrevelocidad, en su caso. Valor de disparo.”

Therefore, the Grid Code as defining the information regarding the WTG protections: **undervoltage, overvoltage, underfrequency, overfrequency and overspeed.**

- COMPLIANCE:

SG 5.X-170:

According to document D3120497 and D2314253 SG 5 X can comply with this requirement.

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5.8. Electrical Simulation Models

- REQUIREMENTS:

The Grid Code requirements related with the electrical simulation models can be found in section 5.2 “MODELOS DE SIMULACIÓN” of the document [2].

Furthermore, the following documents define requirements about the electrical models:

- Section “6. Validación del modelo de Simulación” of the document [4]
- Annex I “Contenido de la base de datos estructural del operador del Sistema”, section 1.4 “Datos necesarios para la realización de estudios dinámicos” of the document [5]
- “Condiciones de validación y aceptación de los modelos” [6]
- “Requisitos de los modelos de instalaciones eólicas, fotovoltaicas, de almacenamiento y de todas aquellas instalaciones que no utilicen generadores síncronos directamente conectados a la red” [7]

According to the SGRE interpretation of the GC, the models required are summarized in the following table:

Item	Value
RMS Model	
WTG RMS model	YES
WFC RMS model	YES
RMS model software	PSS/E and DigSilent (1)
WTG RMS Model validation	YES
WFC RMS Model validation	YES
RMS Model validation standard	Yes Based on section 6 of document [4] and document [6]
Library Model	
WTG Library Model	YES
WFC Library Model	YES
Library models standards	N/A
EMT Model	

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WTG EMT model	YES, Based on section 6 of document [4]
WFC EMT model	YES, Based on section 6 of document [4]
EMT model software	N/A
WTG EMT Model validation	N/A
WFC EMT Model validation	N/A
EMT Model validation standard	N/A
Harmonic Model	
WTG Harmonic model	NO

Table 17 Grid Code required models.

- COMPLIANCE:

The availability of an electrical simulation model for a specific WTG configuration and WFC, in the requested simulation SW (PSS/E, DigSilent, library model parameters) and for a specific purpose (RMS and EMT) can be requested to SGRE. However, the following tables shows validation status:

Item	Value WTG	
Platform	Validation Status according to REE (P.O.9)	Certificated according to NTS
SG 5.X-170	Pending	Pending

Item	Value WFR	
Platform	Validation Status according to REE (P.O.9)	Certificated according to NTS
PMUA	Pending	OK

Remarks:

(1) Grid operator (REE) request PSSe model based on reference [6] and [7] but for running simulations requested in NTS v2.1 [4] any model RMS/EMTvalidated is accepted

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5.9. WF Simulation/Test/Certification

- REQUIREMENTS:

The Grid Code requirements related with the simulation/test/certification can be found in section 4.1. "ASPECTOS GENERALES" of the document [4]

According to the SGRE interpretation of the GC, the requirements are summarized in the following table:

Item	WF Simulation Required	WF Test Required	WTG Certification Required	WFC Certification Required	WF Certification Required	Models included in Certification (2)
Frequency range	No	No	No	No	No	No
Voltage range	No	No	No	No	No	No
Fault Ride Through - UVRT	Yes	No	Yes	No	No	Yes
Fault Ride Through - OVRT	No	No	No	No	No	No
Reactive power capability	Yes	No	Yes	No	No	Yes
Fault current support	Yes	No	Yes	No	No	Yes
Post fault active power recovery	Yes	No	Yes	No	No	Yes
Active power control	No	Yes*	No	Yes	No	No
Frequency control	No	Yes*	No	Yes	No	No
Frequency restoration	No	To be clarified (1)	No	No	No	No
Power factor control	Yes	Yes*	No	Yes	No	No
Reactive power control	Yes	Yes*	No	Yes	No	No
Voltage control	Yes	Yes*	No	Yes	No	No
Power Quality	No	No	No	No	No	No
Inertia Emulation (optional)	Yes	No	No	No	No	No
Power Oscillations Damping	Yes	No	Yes	Yes	No	No

Table 18 Grid Code required Simulation / Test / Certification.

*On site tests may not be required if certification is available.

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- COMPLIANCE:

<u>SG5.X-170:</u>

Information under request on SG5.X-170 WTGs capabilities can be provided to support WF simulations or test.

The required WTG certificate is not yet available for SG5.X-170.

<u>WIND FARM:</u>

Information under request on PPC capabilities can be provided to support WF simulations or test.

The required WFC (PMUA) certificate is already available for PPC.

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5.10. Special Requirements

5.10.1. Phase Jump

- REQUIREMENTS:

The Grid Code requirements related with the capability of withstanding a phase jump, can be found in section 3.3.2 “CAPACIDAD PARA SOPORTAR SALTOS ANGULARES” of the document [2].

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Maximum Phase Jump	º	20

Table 19 Grid Code requirements for Phase Jump.

- COMPLIANCE:

SG5.X-170:

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D3120497 [10]	✔ Compliance

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5.10.2. Inertia Emulation

- REQUIREMENTS:

The Grid Code requirements related with the provision of Inertia Emulation, can be found in section 1.9 “ EMULACIÓN DE INERCIA” of the document [2].

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Applicability of Inertia Emulation requirement	-	Optional (2)
Minimum Required Duration for Additional Active Power - $t_{\Delta P}$	s	8
Minimum Additional Active Power – ΔP	%	10%
Reference for Additional Active Power	-	Prated
Additional active power proportional to frequency deviation	% / Hz	N/A
Additional active power proportional to ROCOF	% / (Hz/s)	N/A
Activation by frequency / ROCOF	-	ROCOF
Frequency activation threshold	Hz	N/A
ROCOF activation threshold	Hz/s	±0.5
Maximum reaction time	s	N/A
Maximum response time - $t_{response}$	s	0.15
Maximum overshoot	%	N/A
Deactivation by frequency / ROCOF	-	Frequency
Frequency deactivation threshold	Hz	±0.5
ROCOF deactivation threshold	Hz/s	N/A
Maximum downwards active power ramp rate	% / s	N/A
Max. Subsequent Power Drop below Pre-disturbance - ΔP_{drop}	%	N/A
Max recovery time between consecutive inertia responses - $t_{recovery}$	s	N/A
Minimum Active Power for Inertia Response Availability - P_{min}	pu	N/A

Table 20 Grid Code requirements for Inertia Emulation.

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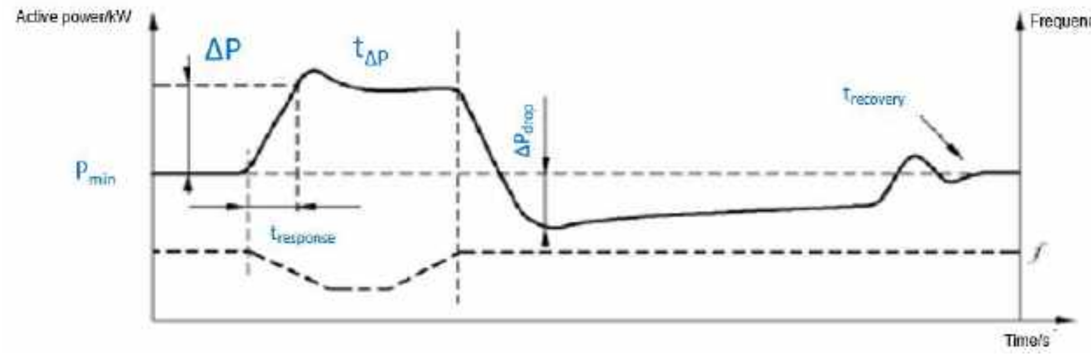

Figure 16 Example of the inertia emulation behavior.

- COMPLIANCE:

SG5.X-170:

According to the correspondent platform documentation, the compliance analysis for a WF with SG5.X-170 WTGs is described in the following table:

WTGs	GD Document	Compliance
SG 5.X-170	D2097474 [12]	✕ Non-compliance(1)

WIND FARM:

SGRE PPC is used to operate the Inertial response and enables SGRE Wind Turbines to provide an overproduction of active power. SGRE PPC cannot comply with all the requirements.

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5.10.3. Power Oscillations Damping (POD)

- REQUIREMENTS:

The Grid Code requirements related with the provision of a Power Oscillations Damping (POD) system can be found in section 2.3.5 “AMORTIGUAMIENTO DE LAS OSCILACIONES DE POTENCIA” of the document [2] and section 5.10 “AMORTIGUAMIENTO DE LAS OSCILACIONES DE POTENCIA EN MPE” of document [4]

5.10.3.1. Acceptance criteria for analysis based on eigenvalues

The criterion for the assessment of the study described in the subsection shall consider that the PPM does not adversely contribute to the damping of oscillation modes between 0.1 Hz and 1.5 Hz if the following conditions are met:

• *The introduction of a PPM in node 1 does not introduce new oscillation modes with a damping of less than 5%.*

• *Under no circumstances will existing modes reduce their damping below 5%.*

- COMPLIANCE:

SG 5.X-170:

SGRE can prepare the models and reports required by TSO according to NTSV2.1 to show compliance with the requirement

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5.10.4. System Strength

- REQUIREMENTS:

The Grid Code doesn't define a minimum System Strength value (short circuit value-SCR), however, in section "Disposición adicional segunda. Valor de los parámetros, porcentajes y ratios contenido en los anexos." of the document [9] defines a SCR value

"Para los nudos con módulos de parque eléctrico existentes o con permisos de acceso concedidos, que no cumplen con el Reglamento (UE) 2016/631 de la Comisión, de 14 de abril de 2016, se fija en 10 el valor mínimo del parámetro WSCR al que se refiere el apartado 4 del anexo I. Para el resto de nudos, dicho valor se fija en 6."

In English:

"For electrical nodes with power park modules under operation or with access permits guaranteed, that do not comply with Regulation (EU) 2016/631 of the Commission, of April 14, 2016, the minimum value of Weighted Short Circuit Ratio (WSCR) will be 10 based on section 4 of annex I. For the rest of electrical nodes, ***this value will be 6****."*"

- COMPLIANCE:

SG5.X-170:

According to document D3120497 [10], the capability of SG5.X-170 to contribute to the WF compliance of this requirement is the following:

Parameter	Value
Min. SCR at WTG MV Terminals **V-Direct operation**	2 **2 > SCR > 1.5**
Min. SCR at WTG MV Terminals **Q-Direct operation**	3 **3 > SCR > 1.5**
Min X/R at WTG MV Terminals **V-Direct operation** **Q-Direct operation**	**3**

Table 21 Standard minimum interconnection electrical characteristics for SG5.X-170.

WIND FARM:

The requirements regarding short circuit ratio (SCR) are specified at the PCC.

Considering this, to ensure compliance a specific study of the whole WF must be carried out in order to analyze the SCR at the WTGs terminals for different operation scenarios of the WF.

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5.10.5. Reconnection Blockage / Synchronization to the Grid

- REQUIREMENTS:

The Grid Code requirements related with the Reconnection Blockage can be found in section "CAPACIDAD TÉCNICA DE RECONEXIÓN TRAS PERTURBACIÓN" of the document [2]

According to the SGRE interpretation of the GC, the key requirements are summarized in the following table:

Item	Unit	Value
Minimum reconnection voltage	p.u	0.9
Maximum reconnection voltage	p.u.	>220 kV - 1.118 < 220 kV -1.1
Minimum reconnection frequency	Hz	47.5
Maximum reconnection frequency	Hz	51.5
Reconnection observation time for the voltage	Sec	Not defined
Reconnection observation time for the frequency	Sec	Not defined
Other reconnection measurement variable	-	N/A
Reconnection based on WF/WTG measurement	-	WF/WTG

Table 22 Grid Code requirements for Reconnection Blockage.

- COMPLIANCE:

The blockage of the automatic reconnection as a function of the grid voltage or frequency is implemented by SGRE at WTG level. If the Grid Operator requests this function at PCC level, it shall be clarified if the SGRE function at WTG level is accepted by the Operator.

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6. Aspects to Clarify

6.1. Active Power/Frequency regulation

The following requirement in the MRPF section 1.8 of document [2] requires clarification:

"1.8. Modo de regulación potencia-frecuencia (MRPF)

(…)

Adicionalmente a lo especificado en cuanto a la monitorización en tiempo real del MRPF en el Reglamento (UE) 2016/631, el módulo de generación de electricidad estará capacitado para recibir en tiempo real del operador del sistema e implementar consignas de potencia en reserva a subir y a bajar mínimas garantizadas, que podrían ser diferentes. En el caso de módulos de parque eléctrico, las consignas de banda a subir y bajar se respetarán en la cuantía que permita la diferencia entre el recurso primario disponible y el nivel mínimo de regulación."

The wording of this requirement is not clear. Since it is in the MRPF section, SGRE understands that the "reserves" mentioned are in fact the "|ΔP1|/Pmax" parameters of the MRPF mode (read screenshot from [2] below) which are available in the SGRE regulation tool. However, note that these parameters are not power reserves but power ranges of operation of the MRPF mode. Moreover, the requirement indicates that these reserves shall be "guaranteed", however, note that a WFs depends on a variable energy source so the SO shall define how they expect a WF to response.

1.8 Modo de regulación potencia-frecuencia (MRPF). En relación con el modo de regulación potencia-frecuencia (MRPF), los módulos de generación de electricidad de tipo C o D deberán ser capaces de activar el suministro de reservas de regulación potencia-frecuencia, de acuerdo con lo especificado a este respecto en el Reglamento (UE) 2016/631, de 14 de abril de 2016. A este respecto, las características estáticas de las respuestas de los modos MRPFL-O y MRPFL-U se acumulan, en su caso, a la característica estática de la respuesta de este modo MRPF.

Salvo indicación en contra del operador del sistema, los parámetros ajustables del MRPF serán los siguientes:

a) Intervalo de potencia activa en relación con la capacidad máxima $|\Delta P_1|/P_{max}$ igual al 8 %.

b) Insensibilidad de respuesta con la variación de frecuencia $|\Delta f_1|$ igual al 10 mHz.

c) Banda muerta de respuesta con la variación de frecuencia igual al 0 mHz.

d) Estatismo s_1 igual al 5 %.

A confirmation of SGRE interpretation of the requirement is necessary. It is important to remark that in case that the SO states SGRE interpretation is not accurate, the requirements shall be analyzed in order to assure compliance.

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6.2. Frequency Restoration

The following test referenced in the NTS [4] appears to be related with the frequency restoration, however, it is not clearly defined. **It shall be clarified if this test applies to WFs and if it does, the test procedure and the technical requirements shall be defined by the SO.**

REQUISITO				FORMA DE EVALUACIÓN	
Artículo [1]	Definición del Requisito	Tipo MGE	Subapartado de la Norma Técnica	MPE	MGES
13.2	Modo regulación potencia-frecuencia limitado-sobrefrecuencia (MRPFL-O)	≥A	5.1	(S y P) o C**	(S y P) o C**
15.2.(a) y (b)	Capacidad de control y el rango de control de la potencia activa en remoto	≥C	5.5	P o C	N/A
15.2.e	Control de potencia-frecuencia	≥C	5.4	P	P

"5.4. Capacidad de control de potencia-frecuencia

El objetivo es verificar que el MGE es capaz de ofrecer funciones que cumplan las especificaciones del GRT, con el objetivo de restablecer la frecuencia a su valor nominal o de mantener los flujos de intercambio de potencia entre las zonas de control en sus valores programados, según lo indicado en:

- Artículo 15.2.e del Reglamento.

En virtud del artículo 45 del Reglamento, la conformidad del MGE con este requisito se podrá realizar a través de prueba, tanto a nivel UGE como MGE, o de certificado de equipo. No obstante, la evaluación de este requisito la realizará el GRT conforme a los protocolos de pruebas establecidos en la regulación vigente en el momento de la puesta en servicio del MGE, que indicará el GRT al propietario del MGE."

The referenced article 15.2.e [3] states the following:

*"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;"*

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7. Summary

The following table reflects the evaluation in terms of Grid Code compliance for a WF comprised of a certain type of WTGs. This summary table is based in **the AM0 of the SGRE WTGs**.

		Section	SG 5.X-170 (9)
			PPC
	Frequency Operation Range	5.1.1	✔ Compliance
	Voltage Operation Range	5.1.2	Wind Farm Study Needed
	Voltage/Frequency Operation Area	5.1.3	Wind Farm Study Needed
	Reactive Power Operation Range	5.1.4	Wind Farm Study Needed
Fault Ride Through	Current Support	5.2.1	✔ Compliance
	Active Power Recovery after Clearance	5.2.2	✔ Compliance
	Consecutive Voltage Dips	5.2.3	✔ Compliance
	Active Power/Frequency Regulation	5.3	To be Clarified (1)(2)(3)
	Reactive Power/Voltage Regulation	0	✔ Compliance (4)
	Power Quality	5.5	Wind Farm Study Needed
	Communications	5.6	To be Clarified (5)
	Protections	5.7	✔ Compliance
	Electrical Simulation Models	5.8	Development in Progress
	WF Simulation / Test / Certification	5.9	✔ Compliance
	Phase Jump	5.10.1	✔ Compliance
	Inertia Emulation	5.10.2	✕ Non-compliance (8)
	Power Oscillations Damping (POD)	5.10.3	Development in Progress
	System Strength	5.10.4	Wind Farm Study Needed
	Reconnection Blockage / Synchronization to the Grid	5.10.5	✔ Compliance

Table 23 Summary.

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Legend	Description
✔ Compliance	Compliance is expected
🛠 Development in Progress	A SCADA or WTG development is planned or underway in order to assure compliance
⚠ Request development upon need	A specific development is required and shall be requested when a project needs to comply with this requirement.
? To be Clarified	The requirement is not clear, or information is missing. Therefore, it shall be clarified with the Operator.
✕ Non-compliance	The requirement cannot be fulfilled.
⏩ Wind Farm Study Needed	Wind Farm Study Needed

Table 24 Legend.

Remarks:

(1) The requirements related with the MRPF and frequency restoration highlighted in sections 6.1 and 0 **must be clarified**.
(2) It must be agreed with SO, the mode of operation of the reactive power/voltage control and its final parameter settings in the corresponding connection agreement.
(3) The final WF signals list should be established in the connection agreement.
(4) **According to Certification Report Fault Ride Through** [13]**,** [14]**,** [15]**,** [16]**, we could comply**
(5) **The Grid Code has only been analyzed against the SG5.X-170. Reference document** [10] **is only valid for 170 rotor diameter variants. The grid capability document for SG5.X-155 variant (155 rotor diameter) is under development.**

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8. References

[1] BOE-A-2020-7439, “Real Decreto 647/2020, de 7 de julio, por el que se regulan aspectos necesarios para la implementación de los códigos de red de conexión de determinadas instalaciones eléctricas”, 08/July/2020.

[2] BOE-A-2020-8965, “Orden TED/749/2020, de 16 de julio, por la que se establecen los requisitos técnicos para la conexión a la red necesarios para la implementación de los códigos de red de conexión, 01/Agust/2020”.

[3] Reglamento (UE) 2016/631 de la comision de 14 de abril de 2016 que establece un codigo de red sobre requisitos de conexion de generadores a la red, 2016.

[4] Norma técnica de supervisión de la conformidad de los módulos de generación de electricidad según el reglamento UE 2016/631, Revisión 2.1, 09/July/2021.

[5] P.O. 9 Información intercambiada por el operador del Sistema, 20/December/2019.

[6] Condiciones de Validacion y Aceptacion de los Modelos, Revision June/2020.

[7] “Requisitos de los modelos de instalaciones eólicas, fotovoltaicas, de almacenamiento y de todas aquellas instalaciones que no utilicen generadores síncronos directamente conectados a la red”, Revision June/2020..

[8] “Requisitos de los modelos de instalaciones FACTS”, Revision June/2020.

[9] BOE-A-2021-904, “Circular 1/2021, metodología y condiciones del acceso y de la conexión a las redes de transporte y distribución de las instalaciones de producción de energía eléctrica.

[10] SG 5.X-170: D3120497, "SGRE ON SG6.2, SG6.6-170 Capabilities"..

[11] SG 5.X PLATFORM: D2904942, "Reactive Power Capaility - 50 & 60Hz.

[12] SG5.X PLATFORM: D2097474, "SGRE ON SG5X Inertial Response".

[13] CR-GCC-NTS631-08094-A066-0 - Fault-ride-through__final.

[14] CR-GCC-NTS631-07893-A066-0 - Fault-ride-through.

[15] CR-GCC-NTS631-07610-A066-0 - Fault-ride-through_final.

[16] CR-GCC-NTS631-08008-A066-0 - Fault-ride-through_final.

i	The latest released version of these documents must always be reviewed.

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