

Febrer 2020

AVANTPROJECTE

PARC EÒLIC

“TOSSAL DE LLANGOST”

TERMES MUNICIPAIS DE MONTOLIU DE SEGARRA, RIBERA
D'ONDARA I TALAVERA

(PROVINCIA DE LLEIDA)

PROMOTOR:

SIEMENS Gamesa
RENEWABLE ENERGY

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1.- ANTECEDENTS I OBJECTIU

GERR Grupo Energetico XXI, SA (GERRSA), pertanyent a SIEMENS-GAMESA, té com a activitat la promoció i la construcció de Parcs Èòlics per a la seva explotació o cessió a tercers.

El present document es redacta per encàrrec de GERRSA com a empresa promotora d'una sèrie de parcs èòlics que opten a concessió segons el *decret llei 16/2019, de 26 de novembre, de mesures urgents per la emergència climàtica i l'impuls de les energies renovables*, que, en el seu capítol IV, regula l'autorització de les instal·lacions de producció d'energia elèctrica provenint d'energia èòlica i d'energia solar fotovoltaica.

En particular, en l'article 11 diu:

“Consulta prèvia sobre la viabilitat de l'emplaçament d'un parc èolic o una planta solar fotovoltaica.

11.1 Les persones interessades a implantar un parc èolic o una planta solar fotovoltaica han de formular una consulta prèvia a la Ponència d'energies renovables sobre la viabilitat de l'emplaçament projectat per a la instal·lació. De manera optativa poden sol·licitar també que la Ponència es pronunciï sobre l'amplitud i el nivell de detall de l'estudi d'impacte ambiental del futur projecte.

11.2 La consulta sobre la viabilitat de l'emplaçament i la sol·licitud de pronunciament sobre l'amplitud i nivell de detall de l'estudi d'impacte ambiental s'han d'efectuar mitjançant l'Oficina de Gestió Empresarial (OGE) i s'ha d'adjuntar la documentació següent:

- a) *Un avantprojecte on es defineixin les característiques i l'emplaçament concret dels aerogeneradors o les plaques fotovoltaiques, la descripció del recurs èolic existent en el cas d'un parc èolic, el traçat soterrat de les línies elèctriques interiors, la línia elèctrica d'evacuació, la subestació del parc o de la planta, l'edifici de control, els vials d'accés i de servei i els terminis d'execució del projecte.*
- b) *Un estudi que realitzi un diagnòstic territorial i del medi afectat pel projecte i justifiqui l'adequació del projecte del parc èolic o planta solar fotovoltaica als criteris dels articles del 7 al 9 d'aquest Decret llei.*
- c) *Un estudi que justifiqui les principals alternatives considerades i que inclogui una anàlisi dels potencials impactes de cadascuna d'elles.*

.....”

Així doncs, l'objectiu del present document es donar resposta al sol·licitat en el punt 11.2.a). pel que fa al Parc Èolic “Tossal del Llangost”, situat en els termes municipals de Montoliu de Segarra, Ribera d'Ondara i Talavera a la província de Lleida.

2.- ABAST

Amb la present documentació es pretén descriure i justificar les característiques bàsiques a les quals hauran d'ajustar-se les instal·lacions del PE “Tossal del Llangost”, sempre d'acord amb el que assenyalen els vigents reglaments que es refereixen a aquest tipus d'instal·lacions.

Es planteja un sistema d'evacuació d'energia consistent en una Subestació 30/220 kV, denominada "Conca Nord", i una Línia Aèria d'Alta Tensió 220 kV, que evacuaran, de manera conjunta, l'energia generada pels Parcs Èòlics “Plans del Dèbol” i “Tossal del Llangost”.

3.- PETICIONARI

El promotor del projecte es GERR Grupo Energetico XXI, SA. amb domicili social al Parc Tecnològic de Biscaia, Edifici 222, 48170, Zamudi (Biscaia) i amb CIF A-25455320.

4.- NORMATIVA LEGAL APLICABLE

En la redacció de la present documentació s'han tingut en compte les Normes i Reglaments que a continuació s'indiquen.

Normativa sectorial

- Decret llei 16/2019, de 26 de novembre, de mesures urgents per la emergència climàtica i l'impuls de les energies renovables Reial decret 413/2014, de 6 de juny, pel qual es regula l'activitat de producció d'energia elèctrica a partir de fonts d'energia renovables, cogeneració i residus.
- Reial decret 1955/2000, d'1 de desembre, pel qual es regulen les activitats de transport, distribució, comercialització, subministrament i procediments d'autorització d'instal·lacions d'energia elèctrica, i les seves posteriors modificacions.
- Ordre ITC/3860/2007, de 28 de desembre, per la qual es revisen les tarifes elèctriques a partir de l'1 de gener de 2008.
- Ordre Ministerial de 29 de desembre de 1997, per la qual es desenvolupen alguns aspectes del Reial decret 2019/1997, de 26 de desembre, pel qual s'organitza i regula el mercat de producció d'energia elèctrica.
- Reial decret 2019/1997, de 26 de desembre, pel qual s'organitza i regula el mercat de producció d'energia elèctrica, i les seves posteriors modificacions.
- Llei 17/2007, de 4 de juliol, per la qual es modifica la Llei 54/1997, de 27 de novembre, del Sector Elèctric, per a adaptar-la al que es disposa en la Directiva 2003/54/CE, del Parlament Europeu i del Consell, de 26 de juny de 2003, sobre normes comunes per al mercat interior de l'electricitat, i les seves posteriors modificacions.
- Llei 24/2013, de 26 de desembre, del Sector Elèctric.

- Obtenció de la condició d'Autogenerador Elèctric (Ordre Ministerial de 7 de juliol de 1982).
- Relacions Tècniques i Econòmiques entre Autogeneradors i Empreses Elèctriques (Ordre Ministerial de 7 de juliol de 1982).
- Normes administratives i tècniques per a funcionament i connexió a les xarxes elèctriques de Centrals de Autogeneració Elèctrica (Ordre Ministerial de 5 de setembre de 1985).

Obra civil i estructures

- Reial decret 314/2006 de 17 de març, pel qual s'aprova el Codi Tècnic de l'Edificació.
- Instrucció de formigó estructural, EHE-08, RD 1247/2008 de 18 de Juliol.

Instal·lacions elèctriques

- Reial decret 223/2008, de 15 de febrer, pel qual s'aproven el Reglament sobre condicions tècniques i garanties de seguretat en línies elèctriques d'alta tensió i les seves instruccions tècniques complementàries ITC-*LAT 01a 09.
- Reial decret 1110/2007, de 24 d'agost, pel qual s'aprova el Reglament unificat de punts de mesura del sistema elèctric.
- Reial decret 842/2002, de 2 d'agost, pel qual s'aprova el Reglament electrotècnic per a baixa tensió i les seves Instruccions tècniques complementàries ITC-*BT.
- Reial decret 337/2014, de 9 de maig, pel qual s'aproven el Reglament sobre condicions tècniques i garanties de seguretat en instal·lacions elèctriques d'alta tensió i les seves Instruccions Tècniques Complementàries ITC-*RAT 01 a 23.
- Instruccions i Normes companyia Subministradora-Distribuïdora.
- Normes UNE-EN.

Normativa ambiental

- Llei 21/2013, de 9 de desembre, d'avaluació ambiental.
- Llei 6/2010, de 24 de març, de modificació del text refós de la Llei d'Avaluació d'Impacte Ambiental de projectes, aprovat pel Reial decret legislatiu 1/2008, d'11 de gener.
- Reial decret 1432/2008, de 29 d'agost, pel qual s'estableixen mesures per a la protecció de l'avifauna contra la col·lisió i electrocució en línies elèctriques d'alta tensió.

Normativa seguretat contra incendis

- RD 2267/2004. Reglament de seguretat contra incendis en establiments industrials.
- DB SI Seguretat en cas d'incendi del Codi Tècnic de l'Edificació.

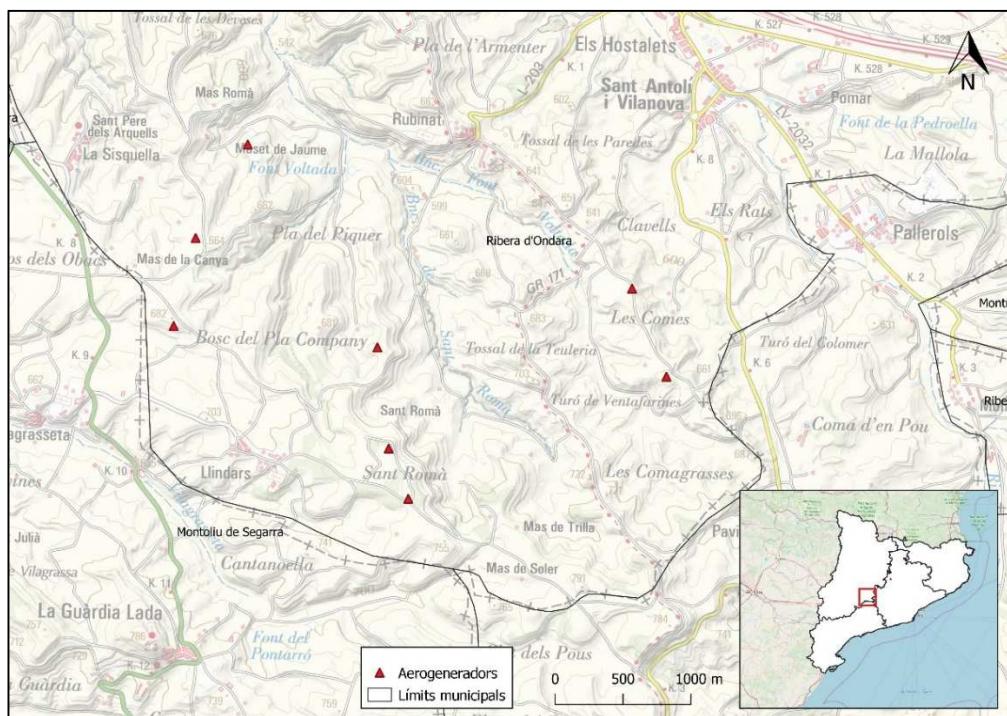
Normativa Gestió de Residus

- RD 105/2008, d'1 de febrer, pel qual es regula la producció i gestió de residus de construcció i demolició.

5.- EMPLACAMENT

Els terrenys on es desenvoluparan les obres i instal·lacions en projecte del Parc Èolic "Tossal del Llangost" es troben situats a la província de Lleida, en la comarca denominada Segarra, dintre dels Termes Municipals de Ribera d'Ondara i Talavera. Els principals paratges compresos en l'àrea del Parc Èolic "Tossal del Llangost" són "*Pla del Piquer*", "*Bosc del Pla Company*", "*Sant Romà*" i "*Les Comes*".

Les instal·lacions del parc èolic "Tossals de Llangost" s'ubicaran als termes municipals de Ribera d'Ondara i Talavera a la comarca de la Segarra (província de Lleida).



Situació del projecte. Fons: Topogràfic del IGN. Elaboració: pròpia.

Les coordenades dels aerogeneradors (UTM. ETRS89-31N) són:

Aerogenerator	X	Y
RO-01	359.585	4.606.740
RO-02	359.441	4.607.110
RO-03	359.358	4.607.855
RO-04	357.857	4.608.013
RO-05	358.019	4.608.661
RO-06	358.403	4.609.349
RO-07	361.487	4.607.640
RO-08	361.234	4.608.288

6.- DESCRIPCIÓ DEL PARC ÈOLIC

La infraestructura eòlica del Parc Èolic "Tossal del Llangost" consta de vuit (8) aerogeneradors del model SG170 de 6.200 kW de potència nominal unitària, amb el que la potència total instal·lada en el parc serà de 49,6 MW. Els aerogeneradors estan dotats d'un sistema de components elèctrics interns, amb les proteccions necessàries per a la seva operació en connexió amb la xarxa.

La disposició sobre el terreny de les màquines es tria atenent a tres tipus diferents de condicionaments:

- Geogràfic (disponibilitat d'espai en la zona).
- Èolic (direcció predominant del vent i a aquest efecte ombra entre les turbines).
- Mediambientals.

L'entorn meteorològic es mesurarà en tot moment mitjançant una torre anemomètrica de mesurament.

Els aerogeneradors es connectaran al centre de control situat en la Subestació "Conca Nord" mitjançant línies de comunicació.

L'obra civil del Parc Èolic "Tossal del Llangost" està formada per:

- Vial d'accés al parc. L'accés al Parc es realitzarà des de tres punts diferents, afectant a les carreteres L-214 i LV-2031. La longitud aproximada del vial d'accés es de 2.760 m. S'executarà sense asfalt amb la finalitat de minimitzar l'impacte ambiental provocat pel mateix.
- Vials Interiors al parc. Partiran del final del vial d'accés i serviran per a arribar a cadascun dels aerogeneradors que constitueixen el parc, aprofitant a el màxim la xarxa de camins existents. S'executaràn sense asfalt amb la finalitat de minimitzar l'impacte ambiental provocat pels mateixos. La longitud aproximada de vials interiors és de 7.090 m.
- Plataformes de Muntatge (8 uds.) Superfícies esplanades de dimensions que permetin l'apilament de viroles, fustos, góndoles i pales, que se situaran en la base dels aerogeneradors, i que a més permetran realitzar el muntatge d'aquests o la maniobra dels vehicles. Les dimensions seran variables en funció de les especificacions detallades del fabricant.
- Fonamentacions dels Aerogeneradors (8 uds.) Per ancoratge de la torre de l'aerogenerador. Els aerogeneradors estaran fonamentats en una sabata de planta circular amb diàmetre 23,2 m i una profunditat de 3,5 m.
- Rases en les quals es disposarà l'estesa de les línies de mitja tensió, les de posada a terra i les de comunicacions en el seu recorregut subterrani. Discorreran per la vora dels vials del parc i disposaran d'amollonament exterior. Si cal travessar camps de conreu, la seva profunditat serà suficient per garantir la continuïtat dels usos agraris de la finca.

La infraestructura elèctrica està constituïda pels següents elements, descrits en el sentit de les turbines cap a la xarxa:

- Centres de Transformació BT/MT (8 uds.) Es disposaran a l'interior dels aerogeneradors i en ells s'eleva la tensió de generació (690 V) a la corresponent de distribució en MT del Parc (30 kV).
- Línies Subterrànies de Mitja Tensió. La finalitat és realitzar la interconnexió dels aerogeneradors entre si i amb la Subestació corresponent. Discorreran, com ja s'ha dit, en rases construïdes en els laterals dels vials dels parcs.
- Línia de Terra. Comuna per a cada Parc Èolic, formant un circuit equipotencial de posada a terra.
- Xarxa de comunicacions: estarà constituïda per conductor de fibra òptica que interconnectarà els aerogeneradors i la torre meteorològica amb el centre de control situat a la Subestació “Conca Nord”.

La xarxa d'interconnexió dels aerogeneradors en mitja tensió i la xarxa de comunicacions s'estenen en canalització subterrània a l'interior de cada parc a fi de minimitzar l'impacte ambiental.

6.1.- RECURS ÈOLIC

L'emplaçament triat per a la ubicació de parc èolic presenta unes bones condicions eòliques. Es troba situat als termes municipals de Montoliu de Segarra, Talavera i Ribera d'Ondara. es tracta d'una zona amb orografia irregular, composta de camps de cultiu i zones d'arbratge, amb cotes que varien entre 680 i 820 m dins de la zona de desenvolupament del parc.

Dades meteorològiques

SIEMENS-GAMESA disposa de torres de mesurament en l'emplaçament de Tossal del Llangost. Així, les dades de velocitat i direcció de vent registrats a les torres s'han utilitzat amb la finalitat d'avaluar el recurs èolic en la zona. Les característiques principals de les torres estan resumides en la següent taula:

Torre	Coordenades UTM ETRS89 (fus 31)		Altitud (m.s.n.m.)	Altures sensors		Orientació sensors (º)	
	X (UTM)	Y (UTM)		Anemòmetres	Penells	Anemòmetres	Penells
E0477	360.682,78	4.604.709,24	813	40,20,10	40,20	225	45
E5076	360.425,78	4.608.270,24	681	49,40,20	49,40	225	45
E5082	357.167,78	4.604.411,31	771	81,78,67,40	81,67	225	45

Estimació a llarg termini

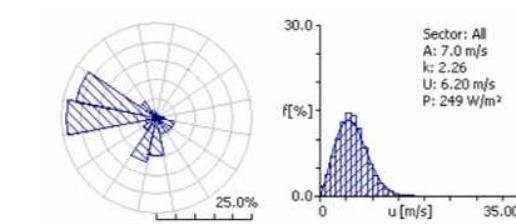
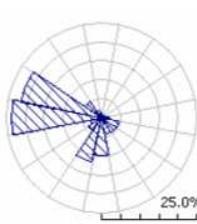
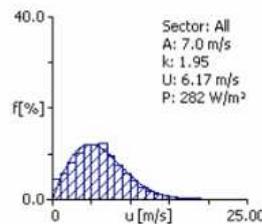
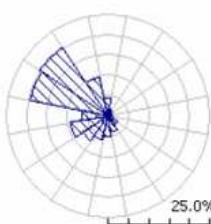
Amb la finalitat de determinar la velocitat a llarg termini, s'han realitzat correlacions de les torres en estudi amb diferents estacions de referència.

Ànalisi del període de referència

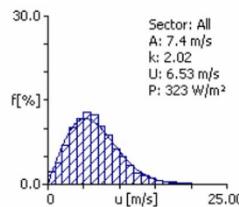
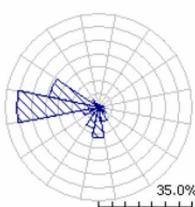
El període de referència seleccionat serà aquell que millor representi les condicions de vent així com la velocitat mitjana registrada en l'emplaçament.

Per a obtenir el període de referència, s'han comparat tots els períodes possibles, formats per anys complets, amb els resultats que s'esperen a llarg termini. El criteri aplicat per a la selecció del període de referència es basa en els següents requeriments:

- La disponibilitat de dades en el període triat ha de ser el major possible.
- El període ha de disposar d'una rosa de vents i una distribució de Weibull representativa a llarg termini.
- La velocitat mitjana del període de referència ha de ser similar a llarg termini.



Rosa de vientos y distribución Weibull de la torre E5082a 81m,



Rosa de vientos y distribución Weibull de la torre E5082a 81m,

S'ha calculat un valor de densitat de l'aire, a altura de boixa, d'1,12 kg/m³. La corba de potència que s'ha utilitzat per a modelització del recurs ha estat la corresponent a una densitat d'1,12 kg/m³ i un nivell de soroll mesurat de 106,4 dB(A).

Resum de resultats

PE TOSSAL DEL LLANGOST	
Nombre d'aerogeneradors	8
Model d'aerogeneradors	SG170
Potència nominal	6.200 kW
Altura de boixa	115 m
Potència total	49,6 MW
Densitat de l'emplaçament	1,12 kg/m ³
Velocitat mitjana	6,75 m/s
HEN (h/año)	2700

6.2.- OBRA CIVIL

Per a la instal·lació i manteniment del Parc Èolic "Tossal del Llangost" cal realitzar una Obra Civil que contempla els següents elements:

- Xarxa de vials del Parc Èolic:
 - ✓ Vials interiors d'accés als aerogeneradors.
- Plataformes per a muntatge dels aerogeneradors.
- Fonamentació dels aerogeneradors.
- Rases per a l'estesa de cables subterrani.
- Obres auxiliars.

Es compartirà, en cas necessari, part de la xarxa de vials del parc i de rases de mitja tensió amb el Parc Èolic "Plans del Dèbol", objecte d'un altre projecte de la mateixa zona (Conca Nord), disminuint d'aquesta forma tant l'impacte mediambiental com el cost total.

6.2.1.- Criteris de disseny

En el disseny de les infraestructures d'obra civil s'han tingut en compte els següents criteris bàsics de disseny tècnics i mediambientals:

Criteris tècnics

- Pendent màxim, amplària, radi de curvatura i tipus de paviment.
- Plataformes i fonamentacions en funció d'l'aerogenerador a col·locar.
- Rases en funció dels circuits elèctrics a canalitzar.

Criteris mediambientals

- La ubicació de les actuacions (implantació d'aerogeneradors i àrees de maniobra, torre de mesurament i obertura de nous vials) es realitzarà, en la mesura del possible, en zones desproveïdes de vegetació natural.
- El disseny de vials s'ha realitzat aprofitant al màxim la xarxa de camins existents i minimitzant el moviment de terres, prevalent les solucions en desmont enfront de les de terraplè i intentant aconseguir un balanç de terres (diferència entre els volums de desmont i terraplè) nul.
- Es revegetaran els talussos en terraplè amb espècies autòctones.
- Els materials d'excavació sobrants es retiraran a un abocador autoritzat.

Aquest punt es desenvolupa a la documentació annexa a l'avantprojecte.

6.2.2.- Vials d'accés i interiors

La xarxa de vials de Parc Èolic està constituïda pel vial d'accés a parc i els vials interiors d'accés als aerogeneradors per al seu muntatge i manteniment.

En el disseny de la xarxa de vials, es procedeix a l'adequació dels camins existents en els trams en què no tinguin els requisits mínims necessaris per a la circulació dels vehicles especials, i en aquells punts on no hi hagi camins es preveu la construcció de nous camins amb les següents característiques:

- Amplària del vial: 6 m. S'aplicaran diferents sobreamples en funció del radi de curvatura, segons especificacions de fabricant de l'aerogenerator.
- Radi mínim de curvatura: 45 m.
- Espessor de ferm en vial en terres: 30 cm de ferm artificial.
- Espessor de terra vegetal 20 cm.
- Pendents màximes: 10 % en rectes, 7% en corbes tancades.
- Desmunts: Talús 1/1, amb arestes arrodonides de radi 2,00 m.
- Terraplens: Talús 3/2, amb arestes arrodonides de radi 2,00 m.
- Roca: Talús 3/2, amb arestes arrodonides de radi 2,00 m.
- Drenatge: mitjançant cunetes en terres de 1 m d'amplada i 0,50 m de profunditat. Als punts baixos relatius de la plataforma, es disposen obres de pas dissenyades amb tub de formigó de diàmetres variables. Es realitzaran cunetes en les plataformes de muntatge que ho requereixin.

Tots els vials s'executaran sense asfalt amb la finalitat de minimitzar l'impacte ambiental provocat pels mateixos. Així mateix, es farà el disseny amb un aprofitament màxim dels vials existents, minimitzant l'afecció resultant.

Vials d'accés

L'accés al Parc Èolic "Tossal del Llangost" es projecta des de tres punts:

- L'accés pròpiament dit parteix de la carretera LV-2031. S'aprofitarà un camí existent denominat "Camí de Lindars", situat a la sortida de la població de Talavera, en direcció Pavia. La longitud total és de 2.760 m.
- Per a arribar als aerogeneradors RO-4, RO-5 i RO-6 els vials interiors partiran directament de la carretera L-214, en el seu PK 8+300 aproximadament, aprofitant un camí existent denominat "Camí de Gramuntell a Rubinat".
- Per a accedir als aerogeneradors RO-8 i RO-9 els vials interiors partiran directament de la carretera LV-2031, en el seu PK 6+200 approximat, aprofitant un camí existent en direcció oest.

L'adequació dels nous accessos des de les carreteres LV-2031 i L-214, permetrà el trànsit rodat dels vehicles de transport especials de subministrament dels aerogeneradors i d'execució de les Obres durant el muntatge del Parc Èolic, necessària i únicament, a través de l'accés projectat. Una vegada finalitzades les Obres del Parc Èolic, es regularà l'accés per vehicles habituals, mitjançant la corresponent senyalització horitzontal i vertical, adequant-se a l'existent en aquest tram de carretera.

Vials interiors

Partiran del final del vials d'accés, aprofitant al màxim la xarxa de camins i serviran per a accés a cadascun dels aerogeneradors que constitueixen el Parc.

El projecte contempla l'adequació dels camins existents en els trams en què no tinguin els requisits mínims necessaris per a la circulació de vehicles de muntatge i manteniment dels aerogeneradors fins a aconseguir les característiques indicades en el punt anterior. Quan això no sigui possible, s'executaran vials de nova construcció.

Tots els vials interns tindran les característiques descrites anteriorment i la seva longitud total serà de 7.090 m aproximadament.

S'intentarà compensar el volum de terres, reutilitzant sempre que sigui possible les terres procedents de l'excavació per als rebliments.

Per minimitzar l'impacte ambiental es revegetaran els talussos de terraplè, mitjançant tècniques d'hidrosembra.

6.2.3.- Plataformes

Les plataformes o àrees de maniobra són explanacions adjacents als aerogeneradors, que permeten millorar l'accés per realitzar l'excavació de la sabata i també l'estacionament de la grua per a muntatge de la torre, que pot així realitzar la seva tasca sense interrompre el pas pel camí, servint al seu torn com a zona d'apilament de materials. Les plataformes de muntatge s'han de fer a la cota en què es vagi a col·locar la base de la torre de l'aerogenerator i s'han previst amb les dimensions i distribució que a continuació es descriuen:

- Plataforma Principal: Àrea de maniobra de la grua principal i auxiliar. Correspon a un rectangle de 3kg/cm² de càrrega portant i unes dimensions de 29x18 m. En aquesta àrea els ferms són de 30 cm de gruix de sòl seleccionat compactada a el 98% del Pròctor modificat.
- Zona per a suport i preparació de la nacelle: Al costat de l'àrea de maniobra de la grua i a la banda de la fonamentació es projectarà una zona per a descàrrega i preparació de la nacelle. Correspon a un rectangle de 25x17,5 m i de 2 kg/cm² de càrrega portant.

- Zona Fonamentació: Al costat de l'àrea de maniobra de la grua i a la banda de la zona per al suport de la nacelle. Correspon a un rectangle de 25x17,5 m i de 2 kg/cm² de càrrega portant.
- Plataforma Pales: Zona per a apilament de pales, davant de la plataforma principal. Correspon a un rectangle de 2 kg/cm² de càrrega portant i unes dimensions de 18x85m. En aquestes àrees no s'aplicarà cap tipus de ferm
- Plataformes Plomes: Àrees per al muntatge de la grua de gelosia. Es realitzarà únicament en les posicions en les que sigui necessària. Correspon a un rectangle de 3x119,5m. En aquestes àrees no s'aplicarà cap tipus de ferm.

L'esplanació del camí i les plataformes, constitueixen les úniques zones de el terreny que poden ser ocupades, devant romandre la resta de el terreny en el seu estat natural.

S'ha intentat que l'excavació a realitzar en totes elles sigui la mínima de forma que una vegada finalitzada la construcció del parc permeti una utilització per a ús agrícola i per tant l'impacte de les mateixes sigui el mínim. Amb aquesta mateixa finalitat s'ha procurat que totes elles se situïn en les parcel·les on es troben els aerogeneradors, atès que sinó es veurien afectats propietaris que no estan beneficiats per la ubicació del parc o la vegetació existent.

Així mateix, s'aprofita el moviment de terres del camí per a incloure aquest dintre de la plataforma de forma que el terreny afectat temporalment es redueix al mínim.

6.2.4.- Fonaments

Els fonaments dels aerogeneradors es realitzaran mitjançant una sabata de formigó armat amb la geometria, dimensions i armat segons les recomanacions del fabricant.

A la definició de la forma i les dimensions dels fonaments, s'ha intentat aconseguir una bona relació pes/resistència al bolc. Els aerogeneradors estarán fonamentats en una sabata circular de 23,2 m de diàmetre i 3,5 m de profunditat. Aquestes dimensions, calculades segons les hipòtesis inicials de l'informe geotècnic, hauran de ser corroborades a través dels estudis de camp a realitzar abans de la construcció del parc.

L'accés dels cables a l'interior de la torre es realitza a través de tubs flexibles posats dins la peanya de formigó. Igualment, a dins de la peanya, s'hi han col·locat tubs de desguàs per evitar que es formin tolls d'aigua a l'interior de la torre. Per facilitar l'evacuació de l'aigua a través dels desguassos, s'ha donat una certa inclinació a la superfície dels fonaments.

En el plànol de Planta General es presenten les localitzacions de les cimentacions dels aerogeneradors sobre el terreny

6.2.5.- Rases

Seran fetes pel contractista d'obra civil i tindran per objecte allotjar la línia subterrània a 30 kV, la xarxa de terra i la línia de comunicacions que interconnecta tots els aerogeneradors del Parc.

Les canalitzacions es disposaran junt amb els camins de servei al costat més proper als aerogeneradors. Si cal travessar camps de conreu, la seva profunditat serà suficient per garantir la continuïtat dels usos agraris de la finca. Per això i per evitar formigonar aquests trams, la profunditat de la rasa en aquestes zones serà de 1,30 m. A les zones de plataformes, les rases passaran per la vora de l'esplanació. Les seves dimensions, en funció dels circuits allotjats i de la zona a creuar, es reflecteixen a la llista adjunta.

Nº Circuits	Rasa a terra			Rasa de cruïlla		
	Amplada (m)	Profunditat (m)	Gruix sorra (m)	Amplada (m)	Profunditat (m)	Gruix formigó (m)
1	0,60	1,10	0,40	0,60	1,20	0,50
2	0,60	1,10	0,40	0,60	1,20	0,80
3	0,90	1,10	0,40	0,60	1,20	0,80

Aquestes dimensions permeten l'allotjament dels cables necessaris de mitja tensió, terres i de comunicacions.

Les fites de senyalització aniran situats en els entroncaments, cada 50 metres i en els canvis de direcció de les rases. Les fites són de planta quadrada de 15 cm i una longitud de 75 cm i aniran enterrats 50 cm en el terreny natural. Són de formigó prefabricat.

La secció tipus de les rases està representada en el plànol Nº 6.- Rases tipus.

6.2.6.- Obres auxiliars

Les obres auxiliars seran totes aquelles obres que no siguin estrictament l'execució dels vials interiors tal com reposició de voltes, tanques i murs de maçoneria, adequació dels entroncaments dels camins existents i/o a finques particulars amb la rasant dels vials dissenyats, reparació i/o reposició d'elements existents (arquetes, canonades de reg, etc).

6.3.- INFRAESTRUCTURA ELÉCTRICA

En aquest apartat, s'hi descriu la infraestructura elèctrica necessària per a l'evacuació de l'energia produïda pels aerogeneradors a la Subestació "Conca Nord", segons l'esquema següent:

- Centres de Transformació a l'interior dels aerogeneradors.
- Línies subterrànies d'interconnexió dels aerogeneradors amb les línies de 30 kV fins a la Subestació "Conca Nord".
- Xarxa de terres del parc.
- Xarxa de comunicacions.

L'evacuació de l'energia generada es realitzarà a través de la Subestació 30/220 kV "Conca Nord" i la Línia Aèria d'Alta Tensió 220 kV, sent ambdues instal·lacions objecte de projectes independents.

6.3.1.- Característiques generals de l'aerogenerador

S'instal·laran vuit (8) aerogeneradors de 6.200 kW de potència unitària, resultant una potència autoritzada de 49,6 MW, del fabricant SIEMENS-GAMESA. Les seves principals característiques es reflecteixen en la següent taula:

Potència unitària (kW)	6.200
Tensió de generació (kV)	0,69
Freqüència de xarxa (Hz)	50
Altura de Boixa (m)	115
Diàmetre de Rotor (m)	170
Pales	Fibra de vidre reforçada amb polièster
Nombre de pales	3
Longitud pales (m)	83

6.3.2.- Centres de transformació

S'ubicaran a la base de cadascun dels aerogeneradors i serviran per elevar l'energia produïda de la tensió de generació (690 V) fins a la tensió de distribució de l'interior del Parc (30 kV), així com per a realitzar les connexions entre les diferents línies que componen la xarxa de 30 kV i dotar-la de les proteccions adequades.

Els elements presents a cada centre de transformació es descriuen a continuació.

Cel·les

S'instal·laran cel·les compactes o bé modulars amb les funcions típiques de protecció de transformador, remuntador i línia (zero, una o dues, segons el cas), de dimensions reduïdes (per permetre el pas a través de les portes de les torres), sota embolcall metàl·lic hermèticament segellades i plenes de gas aïllant SF₆ en la seva totalitat o en els agents de tall. Compliran amb les normes UNE 20099, CEI 298 i RU 6407.

La cel·la o funció de protecció es destina a protegir el costat de M.T. dels transformadors i a separar-los del circuit en cas d'operació o avaria del transformador. Cada cel·la es connectarà a la línia general mitjançant connectors cargolables, amb pantalla o no i al transformador mitjançant connectors endollables amb pantalla.

Característiques elèctriques de les cel·les:

- Tensió nominal: 36 kV
- Freqüència nominal: 50 Hz
- Tensió suportada 1 min./50 Hz: 70 kV
- Tensió d'impuls entre fases i terra: 170 kV (punta)
- Intensitat nominal: 630 A
- Màxima intensitat de curt circuit (valor cresta): 40 kA
- Màxima intensitat de curta durada (1 seg.): 16 kA

Contingut de les cel·les:

- Interruptor seccionador trifàsic de tres posicions: connectat – disconnectat - posada a terra, tensió nominal 36 kV, intensitat nominal 630 A, màxima intensitat de curta durada (1 seg.) 16 kA, capacitat de tancament sobre curt circuit 40 kA, comandament manual mitjançant palanca
- Interruptor automàtic trifàsic de tres posicions: connectat – disconnectat - posada a terra tensió nominal 36 kV, intensitat nominal 630 A, intensitat de curta duració 16 kA, capacitat de tancament sobre curt circuit 40 kA (funció de protecció de transformador)
- Detectors capacitius de presència de tensió a cada fase.
- Barres generals.
- Barra de terres.
- Connexió dels cables d'entrada i sortida.

Quantitats i tipus de cel·les:

- 3 cel·les prefabricades de tall en SF₆ (esquema 0L+1V), que contenen interruptor automàtic per a protecció de transformador, amb tres transformadors toroïdals i un relé electrònic sense alimentació auxiliar VIP 35, amb embarrat de Mitja Tensió (M.T.) i una sortida per connectors directa des de l'embarrat (funció de remuntador).

Els aerogeneradors, en els quals s'instal·la aquest tipus de cel·les, són els corresponents als extrems dels diferents ramals que, segons els plànols adjunts, es corresponen amb els enumerats com a: RO-3, RO-6 i RO-8.

- 5 cel·la prefabricada de tall en SF₆ (esquema 0L+1L+1V), que contenen interruptor automàtic per a protecció de transformador, amb tres transformadors toroïdals i un relé electrònic sense alimentació auxiliar VIP 35, amb embarrat de Mitja Tensió (M.T.), una sortida per connectors directa des de l'embarrat (remuntador) i una sortida per connectors a través d'interruptor seccionador (línia).

Els aerogeneradors, en els quals s'instal·la aquest tipus de cel·les, són els corresponents a posicions d'entrada/sortida dins d'un ramal que, segons els plànols adjunts, es corresponen amb els enumerats com a: RO-1, RO-2, RO4, RO-5 i RO-9.

Si la solució adoptada és amb cel·les modulars, el nombre de cel·les es correspondrà amb les funcions (protecció, línia i remuntador) necessàries per a cada turbina segons el disseny de circuits.

Central d'alarmes de les sondes PT-100

La centraleta d'alarmes per a les sondes PT-100 s'instal·larà en un armari metàl·lic i disposarà de dos nivells de temperatura programables per alarma i disparament respectivament. S'inclourà el cablejat per a l'alimentació a 220 V C.A. des del quadre de control, per a la presa de senyal des de les sondes i per a la connexió amb la bobina de disparament de la cel·la de M.T.

Transformador

En cadascun dels 8 aerogeneradors, es preveuen els corresponents transformadors de potència tipus sec, encapsulat en resina epoxy de 7.200 kVA, relació 690 / 30.000 ± 8%-10 % V, per a elevar la tensió de l'energia elèctrica generada des de la tensió de generació a la de la xarxa col·lectora de mitja tensió.

Les característiques del transformador són les següents:

- Potència nominal 7.200 kVA
- Tipus Aïllament sec.
- Relació de transformació: 0,69 / 30 kV ± 8%-10 %
- Tensió nominal primària 30 kV
- Tensió nominal secundaria..... 0,690 kV
- Freqüència 50 Hz
- Nivell d'aïllament..... 36 kV
- Grup de connexió Dyn11
- Impedància 10,6%

Material de seguretat

Amb la finalitat de contribuir a la seguretat en les maniobres, a la prevenció i extinció d'incendis i a la informació sobre els riscos elèctrics derivats de la manipulació incorrecta dels aparells, s'instal·laran els següents elements:

- Malla metàl·lica de separació del transformador.
- Guants aïllants.
- Perxa de salvament.
- Placa de primers auxilis.
- Senyalització de risc elèctric.
- Banqueta aïllant.
- Armari de primers auxilis.
- Extintor contra incendis de 5 Kg. de CO₂

6.3.3.- Posada a terra de les masses de l'aerogenerador

Posada a terra de totes les masses de l'aerogenerador mitjançant cable de coure tipus RV 0,6/ 1 kV de 1 x 50 mm², amb terminals de connexió a compressió als dos extrems, unint amb el punt de connexió a terra de l'aerogenerador amb els següents elements: neutre del transformador, estructura metàl·lica del transformador, embolcall metàl·lic, cel·la de MT i quadre de control de l'aerogenerador, així com totes les pantalles dels conductors de MT.

6.3.4.- Protecció contra sobreintensitats

Per a la protecció contra sobreintensitats s'utilitzaran interruptors automàtics col·locats al començament de les instal·lacions que alimenten cables subterrànies. Les característiques de funcionament d'aquests elements de protecció correspondran a les exigències que presenti el conjunt de la instal·lació de la qual forma part el cable subterrani.

6.3.5.- Xarxa subterrània de mitja tensió

Es farà amb cable d'alumini HEPRZ1 18/30 kV de seccions 95, 240, 400 i 630 mm².

S'adaptarà a la càrrega a cada tram, de forma que les pèrdues siguin inferiors al 3 %, que la potència transportada pel cable no excedeixi en cap cas el 100 % de la seva capacitat nominal per a les condicions d'instal·lació (segons les recomanacions del fabricant) i que es respectin els criteris reglamentaris de caiguda de tensió.

Es tracta d'un cable d'alumini unipolar aïllat amb etilè propilè d'alt mòdul (HEPR), amb pantalla amb fils de coure de 16 mm², no armat i amb coberta exterior de color vermell de 2 mm de gruix realitzada amb barreja de poliolefines segons UNESA 3305 C i UNE HD 620.

A títol indicatiu, les característiques principals d'aquest cable són les següents:

Característiques	Secció (Alumini 18/30 kV)			
	95 mm ²	240 mm ²	400 mm ²	630 mm ²
Diàmetre del conductor (mm)	11,2	17,9	23,1	30,0
Diàmetre exterior (mm)	34,4	40,4	45,7	52,2
Pes (Kg./Km.)	1.330	1.900	2.550	3.070
Resistència elèctrica màxima 20º C (Ω/Km.)	0,320	0,125	0,078	0,047
Resistència a 50 Hz i 105º C (Ω/Km.)	0,430	0,168	0,105	0,060
Reactància a 50 Hz per fase (Ω/Km.)	0,129	0,109	0,102	0,093
Capacitat (μF/Km.)	0,204	0,301	0,367	0,382
Càrrega màxima admissible en servei permanent en ampers (A) corresponent a tres cables unipolars agrupats en instal·lació enterrada 1 m de profunditat, temperatura del terreny 25º C	215	365	470	615

El traçat i la longitud de les línies subterrànies de M.T., així com el detall de les rases que les acullen es poden consultar als plànols adjunts d'aquest projecte.

Les longituds i seccions de cable seran:

- 4.310 metres cable HEPRZ1 3x1x95 mm² Al 18/30 kV.
- 1.810 metres cable HEPRZ1 3x1x240 mm² Al 18/30 kV.
- 5.790 metres cable HEPRZ1 3x1x400 mm² Al 18/30 kV.
- 12.190 metres cable HEPRZ1 3x1x630 mm² Al 18/30 kV.

L'estesa dels cables subterrànies es farà a l'interior de les rases amb les característiques i dimensions especificades a l'apartat 6.2.5. S'ha procurat que la longitud del cable sigui la més curta possible, mitjançant trams rectes i evitant angles pronunciats, de fàcil accés i que passi pels vials del Parc i pels terrenys de domini públic.

Al fons de la rasa, s'hi estendrà una capa de 10 cm de sorra, sobre la qual s'estendran els cables per a ser recoberts posteriorment amb una capa de 30 cm de sorra tamisada. La rasa s'omplirà amb materials seleccionats procedents de l'excavació degudament compactats. A 30 cm de profunditat, s'hi col·locarà una cinta de polietilè per a senyalització amb la indicació “Canalització Elèctrica d'Alta Tensió”.

A les cruielles amb els vials i, en general, en totes aquelles zones de la canalització sobre les quals es prevegi trànsit rodat, s'estendran els cables a l'interior de tubs de PVC de 200 mm de diàmetre recoberts de formigó.

Per a l'accés a l'interior dels aerogeneradors s'utilitzaran tubs de plàstic col·locats al formigó del pedestal dels fonaments.

Es col·locaran fites de senyalització en els entroncaments, cada 50 m i en els canvis de direcció de les rases.

Accessoris

Els empalmaments i les terminacions seran adequats a la naturalesa, composició i secció dels cables i no hauran d'augmentar la resistència elèctrica. Les terminacions també hauran de ser adequades a les característiques ambientals (interior, exterior, contaminació, etc.)

Els terminals corresponents a les cel·les de M.T. als aerogeneradors per al cable d'alumini HEPRZ1 18/30 kV, consisteixen en 13 unitats de tres connectors unipolars de terminals cargolables recolzats per a les entrades i sortides de línies i 8 unitats d'un Kit de tres connectors unipolars endollables per a la connexió amb el transformador 0,69/30 kV de l'interior de la torre.

Es realitzaran seguint la Norma corresponent si existeix o, sinó n'hi ha, les instruccions del fabricant.

6.3.6.- Sistema de control

El Parc Èolic disposa d'un sistema de control global, que interconnecta els sistemes de control individuals amb un mòdul central, a fi de monitoritzar des d'aquest el funcionament de la instal·lació.

Els components principals del sistema són:

- Els mòduls individuals situats en els armaris de control de l'aerogenerator. En ells se supervisa el funcionament de cada màquina.
- Les línies de comunicacions (cables de control i comandament) que, canalitzades conjuntament amb els cables d'energia en esteses subterrànies, interconnecten els components descrits amb el centre de control. La transmissió de dades es realitzarà per mitjà de fibra òptica.

- El centre de control, situat en l'edifici de la Subestació “Conca Nord”, on es disposa l'equip electrònic i informàtic necessari per a la interconnexió dels components descrits i subsistemes auxiliars associats. Des d'aquest centre es controla l'operació de tot el parc, al mateix temps que es registren els paràmetres de funcionament més rellevants, per al seu tractament informàtic.

Una dels avantatges derivats de la instal·lació d'un sistema centralitzat és la facilitat de realització de les tasques de manteniment, perquè es pot esbrinar, sense haver de desplaçar-se a una turbina, les causes d'un error en la seva operació.

En el centre de control es disposa d'un mòdem a fi de connectar un programa de comunicació remota. Amb això es podrà efectuar el control del Parc Èolic des d'un emplaçament extern a aquest.

6.3.7.- Xarxa de terres

El sistema de posada a terra serà únic per a la totalitat del Parc Èolic.

Comprendrà, així mateix, les terres de protecció i de servei segons la ITC-RAT-13, apartat 6.

La posada a terra, a més d'assegurar el funcionament de les proteccions, garanteix la limitació del risc elèctric en cas de defectes d'aïllament, mantenint les tensions de pas i de contacte per sota dels valors admissibles; segons la ITC-RAT-13.

Basant-se en les recomanacions sobre instal·lació general de posada a terra donades pel fabricant dels aerogeneradors, s'adulta com a solució realitzar una estesa general, que passi per les rases dels cables elèctrics, amb conductor de coure nu de 50 mm² de secció.

Sistema generador

La línia principal de protecció serà de 50 mm², aïllada, connectant tots els elements metàl·lics: cel·les de M.T; armadura sabata, torre, plataformes, ferratges, estructura envolupant del transformador, quadres i uns altres.

A la principal de servei, anàloga a l'anterior, s'establiran connexió els neutres dels transformadors i del generador.

Es preveu, a l'interior de la torre dels aerogeneradors, una caixa per a verificació i connexió de les terres.

Sistema col·lector

Discorreix pel mateix itinerari que les rases que contenen la línia de M.T., enllaçant els aerogeneradors amb la subestació.

Es resol amb cable de coure nu de 1x50 mm² de secció, enterrat a 1,10 m de profunditat, fins a conseguir la caixa de verificació de la subestació.

Unions

Totes les unions entre conductors i entre aquests i piques, es realitzaran mitjançant soldadura aluminotèrmica.

6.3.8.- Xarxa de comunicacions del parc

Els aerogeneradors s'uniran entre si i a l'edifici de control de l'edifici de Control del Parc Èolic i amb la Subestació "Conca Nord", mitjançant fibra òptica. Queda fora de l'abast d'aquest projecte l'especificació del tipus de material per instal·lar, així com els elements de connexió o derivació de fibra òptica.

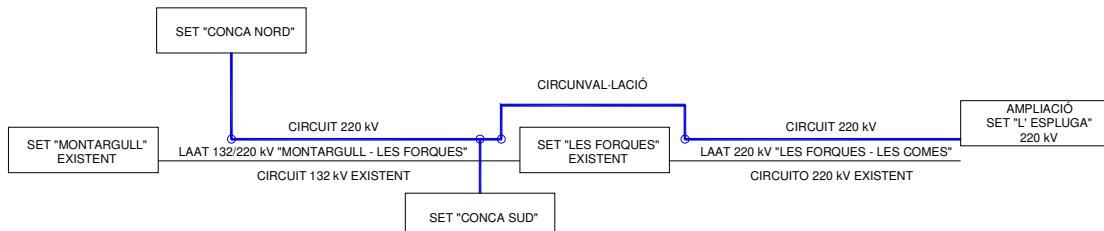
7.- INFRAESTRUCTURA D'EVACUACIÓ

Es planteja un sistema d'evacuació d'energia consistent en una Subestació 30/220 kV, denominada "Conca Nord", i una Línia Aèria d'Alta Tensió 220 kV, que evacuaran l'energia generada pels Parcs Eòlics "Plans del Dèbol" i "Tossal del Llangost".

És necessari assenyalar que aquesta línia realitza connexió amb la línia aèria d'alta tensió "Montargull-Les Forques" existent, on discorreran de forma conjunta, compartint un circuit que s'estendrà a tal efecte. Els suports de la línia estan preparats per a l'estesa d'un circuit addicional, encara que es modificaran en cas necessari per permetre l'estesa d'aquest circuit.

El nou circuit circumval·larà la SET "Les Forques", existent, mitjançant suports en projecte, realitzant connexió amb la línia aèria 220 kV " Les Forques-Les Comes" existent. Aquesta línia està preparada per a dos circuits però actualment només hi ha estès un circuit, per la qual cosa la línia en projecte podrà discórrer per circuit a tendir a l'efecte. Aquest circuit finalitzarà en posició de línia 220 kV prevista a la futura ampliació de la SET "L'Espluga".

A continuació es mostra un esquema amb les instal·lacions descrites:



A continuació es presenta un breu resum de les característiques principals de la subestació i la línia, La descripció detallada de la infraestructura d'evacuació i el cost total de les instal·lacions de la ZDP II Conca Nord pot consultar-se al projecte PE "Plans del Dèbol".

7.1.- SUBESTACIÓ ELÈCTRICA TRANSFORMADORA “CONCA NORD”

La Subestació Transformadora 30/220 kV “Conca Nord”, evacuarà l'energia elèctrica generada pels parcs eòlics de “Plans del Dèbol” y “Tossal del Llangost”. Tal com pot veure's en plànols adjunts, es troba ubicada al terme municipal de Talavera (Província de Lleida).

A la següent taula hi ha definit el llistat de coordenades UTM de les quatre cantonades de la Subestació “Conca Nord”, referides al fus 31:

COORDENADES UTM		
VÈRTEX	XUTM	YUTM
1	360.011	4.604.339
2	360.039	4.604.377
3	360.105	4.604.328
4	360.076	4.604.290

A continuació es presenta una taula amb les principals característiques dels diferents nivells de tensió en la S.E.T. “Conca Nord”:

CARACTERÍSTIQUES DE L'APARELLATGE		
NIVELL DE TENSIÓ DEL PARC	220 kV	30 kV
Tipus de construcció	Intempèrie	Interior
Tensió nominal	220 kVef	30 kVef
Tensió més elevada per al material	245 kVef	36 kVef
Freqüència	50 Hz	50 Hz
Tensió suportada a freqüència industrial	460 KVef	70 kVef
Tensió suportada sota impuls tipus llamp	1050 KVef	170 KVef
Connexió del neutre	Rígid a terra	Aïllat
Intensitat nominal d'embarrat	2000 A	1250 A
Intensitat nominal de posició de línia	2000 A	630 A
Intensitat nominal de posició de transformador	2000 A	1250 A
Intensitat màxima de defecte trifàsic	50 KA	31,5 KA
Durada màxima del defecte trifàsic	1 s	1 s

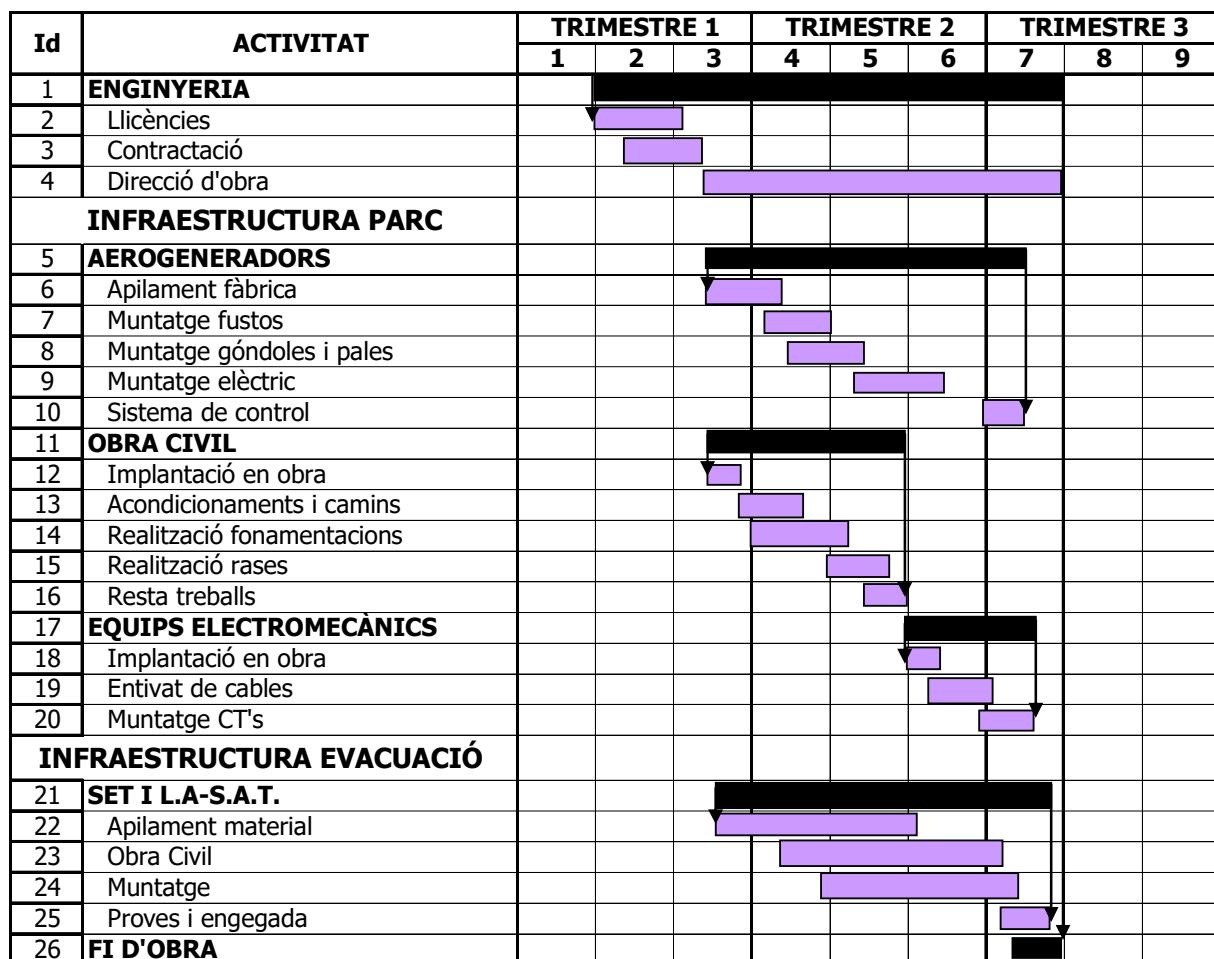
7.2.- LÍNIA AÈRIA D'EVACUACIÓ PER A LA SET "CONCA NORD"

- Tensió nominal 220 kV
- Tensió mes elevada..... 245 kV
- Núm. de circuitsUn
- Nº de conductors per faseUn
- Disposició conductors..... A portell
- Zona de càlculB
- Conductors per circuit..... Tres
- Cables de terra Un, Cable compost OPGW53G68Z
- Aïllament..... Bastons polimèrics de cautxú silicona
- Posada a terra de suportsElèctrode de difusió o anell difusor

8.- TERMINI D'EXECUCIÓ DEL PROJECTE

El termini d'execució de les obres que es refereix el present document és de 6 mesos, a partir de la signatura de l'acta de replanteig.

El "planning" del Projecte es representa en la següent figura.



9.- CONCLUSIONS

Amb l'exposat anteriorment en la present memòria, pressupostos, plànols i altres documents adjunts, es consideren suficientment descrits els elements constitutius i les actuacions constructives derivades de la instal·lació i funcionament del Parc Èolic "Tossal del Llangost'", així com la línia d'evacuació i la subestació transformadora precisa.

L'Enginyer Industrial al servei de SATEL
David Gavín Asso
Col·legiat N°15.212 del C.O.E.I.C.

ANNEX 1.- DOCUMENTACIÓ AEROGENERADOR



SG 6.0-170 Developer Package

SIEMENS Gamesa
RENEWABLE ENERGY

Developer Package SG 6.0-170

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 (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 6.0-170 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. Information contained within the Developer Package may not be treated separately or out of the context of the Developer Package.

The information contained in the Developer Package may not be used as legally binding documentation and cannot be used in contracts between SGRE and any other parties. This Developer Package contains preliminary technical data on SGRE turbines currently under development and can be used in an indicative capacity only.

All technical data is subject to change according to the technical development of the wind turbine.

SGRE and its affiliates reserve the right to change the below specifications without prior notice.

Developer Package

SG 6.0-170

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Introduction

The SG 6.0-170 is a new wind turbine of the next generation Siemens Gamesa Onshore Geared product series, which builds on the Siemens Gamesa design and operational experience in the wind energy market.

With a new 83m blade, a 6.0 MW generator and an extensive tower portfolio including hub heights such as 100m, 115m, 135m and 165m, the SG 6.0-170 aims at becoming a new benchmark in the market for efficiency and profitability.

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

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

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

The SG 6.0-170 blade is 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 SG 6.0-170 blade uses 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 spherical 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 high speed side 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.

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.

High wind derated mode (HWRT) is a default functionality. When active 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.

Technical Specifications

Rotor

Type	3-bladed, horizontal axis
Position	Upwind
Diameter.....	170 m
Swept area	22,698 m ²
Power regulation	Pitch & torque regulation with variable speed
Rotor tilt.....	6 degrees

Blade

Type	Self-supporting
Blade length	83 m
Max chord	4.5 m
Aerodynamic profile	Siemens Gamesa proprietary airfoils
Material	GRE (Glassfiber Reinforced Epoxy) – 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.....	Forged steel
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 .	6.0 MW
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	100m 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

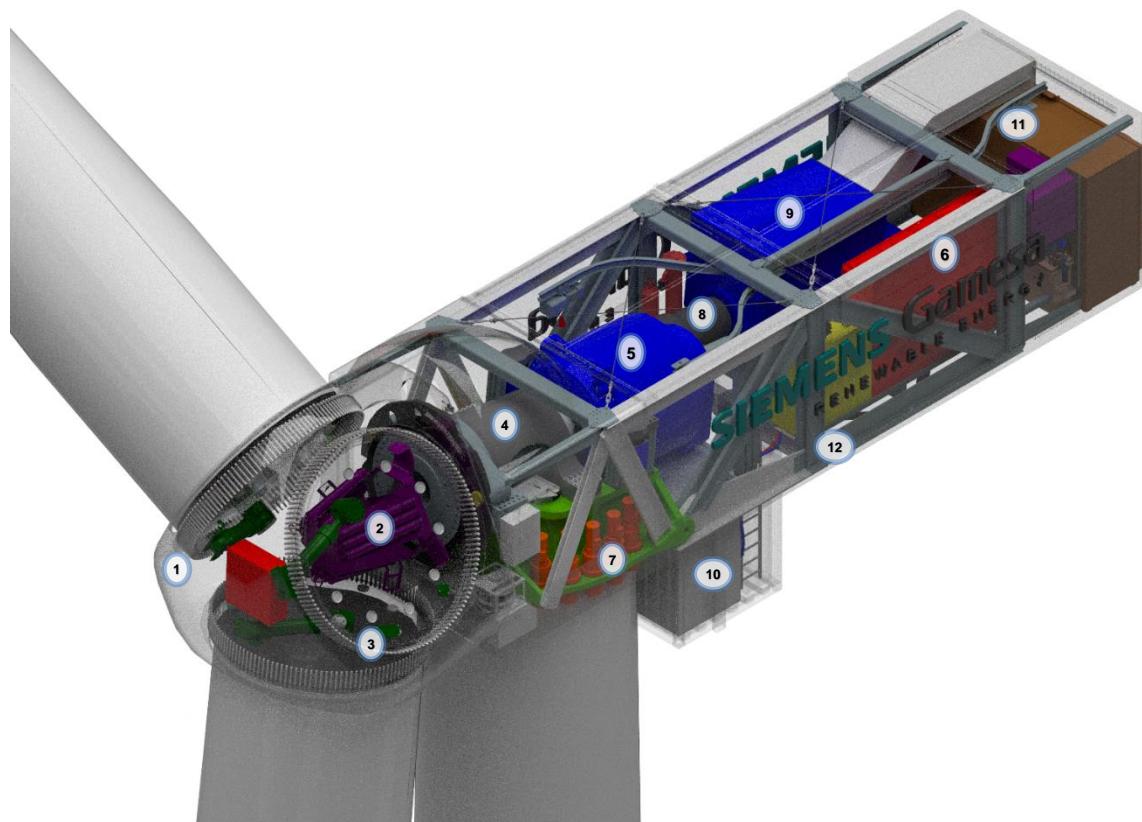
Cut-in wind speed	3 m/s
Rated wind speed	10.0 m/s (steady wind without turbulence, as defined by IEC61400-1)
Cut-out wind speed	25 m/s
Restart wind speed.....	22 m/s

Weight

Modular approach.....	All modules weight lower than 80 t for transport
-----------------------	--

Nacelle Arrangement

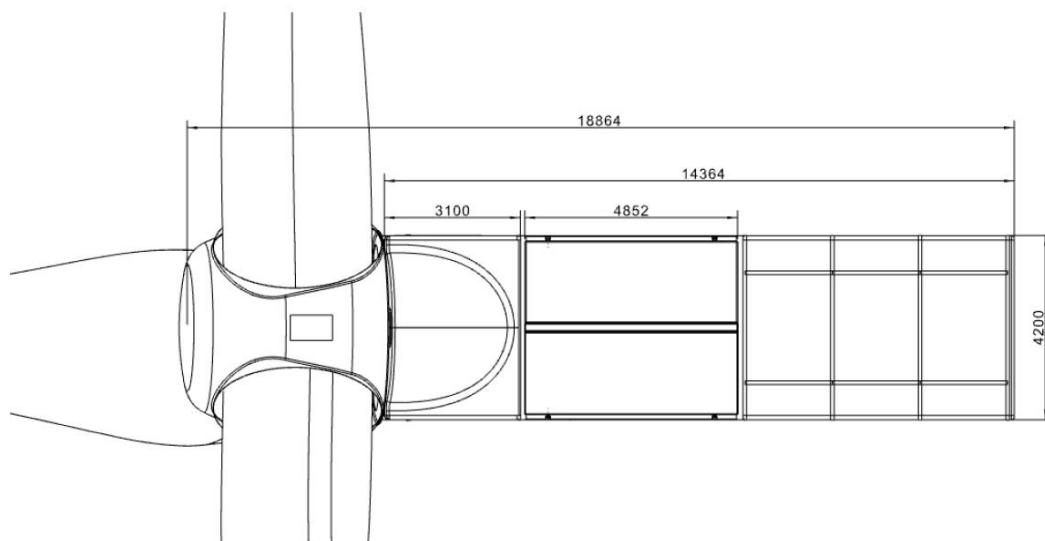
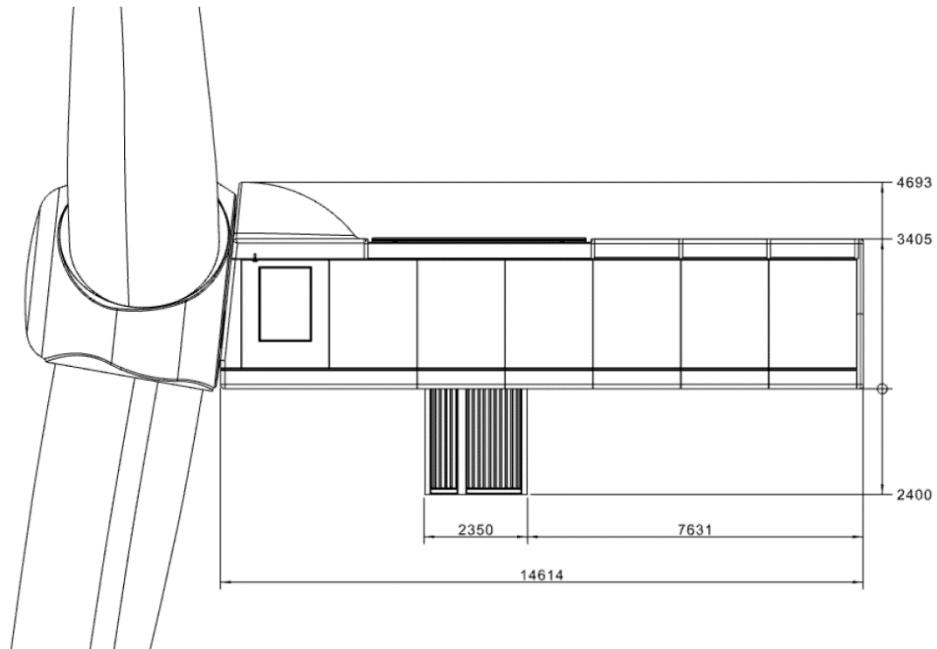
The design and layout of the nacelle are preliminary and may be subject to changes during the development of the product.



- | | |
|------------------------------|---------------------------|
| 1 Hub | 7 Yaw system |
| 2 Pitch system | 8 High speed shaft |
| 3 Blade bearings | 9 Generator |
| 4 Low speed shaft | 10 Transformer |
| 5 Gearbox | 11 Cooling system |
| 6 Electrical cabinets | 12 Rear Structure |

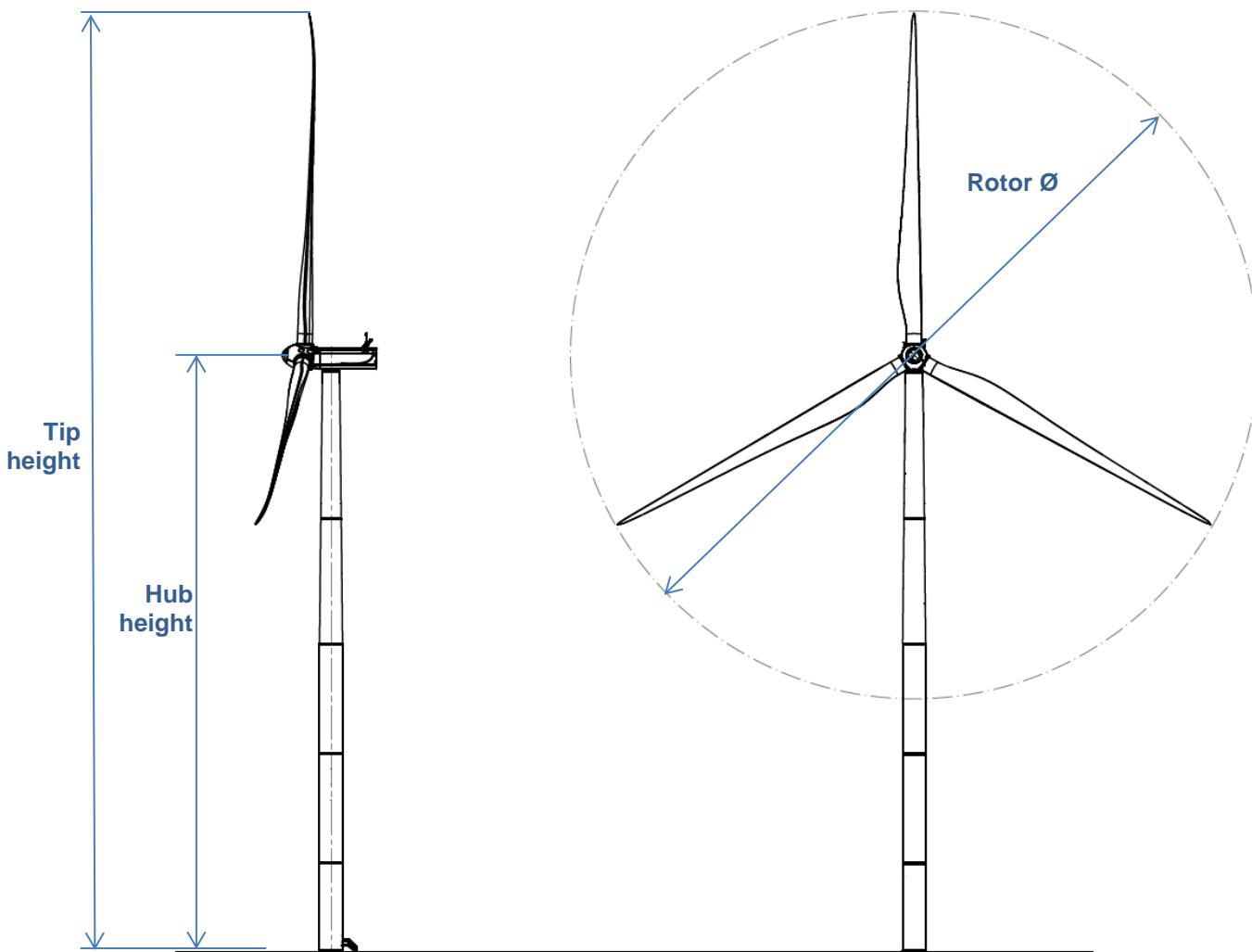
Nacelle Dimensions

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



Dimensions in millimeter.

Elevation Drawing



Tip height	185m, 200m, 220m, 250m, and site specific
Hub height	100m, 115m, 135m, 165m, and site specific
Rotor diameter	170m

Blade Drawing



Dimensions in millimeters.

Design Climatic Conditions

The design climatic conditions are the boundary conditions at which the turbine can be applied without supplementary design review. Applications of the wind turbine in more severe conditions may be possible, depending upon the overall circumstances. A project site-specific review requires that the Employer complete the "Project Climatic Conditions" form.

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 61400-11
	0.1	Design lifetime	years	20 25
1. Wind, operation	1.1	Wind definitions	-	IEC 61400-1
	1.2	IEC class	-	IIIA IIIB
	1.3	Mean air density, ρ	kg/m ³	1.225 1.225
	1.4	Mean wind speed, V_{ave}	m/s	7.5 7.5
	1.5	Weibull scale parameter, A	m/s	8.46 8.46
	1.6	Weibull shape parameter, k	-	2 2
	1.7	Wind shear exponent, α	-	0.20 0.20
	1.8	Reference turbulence intensity at 15 m/s, I_{ref}	-	0.16 0.14
	1.9	Standard deviation of wind direction	Deg	8 8
	1.10	Maximum flow inclination	Deg	8 8
	1.11	Minimum turbine spacing, in rows	D	3 3
	1.12	Minimum turbine spacing, between rows	D	5 5
2. Wind, extreme	2.1	Wind definitions		IEC 61400-1
	2.2	Air density, ρ	kg/m ³	1.225
	2.3	Reference wind speed average over 10 min at hub height, V_{ref}	m/s	37.5
	2.4	Maximum 3 s gust in hub height, V_{e50}	m/s	52.5
	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 ²
	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)	-	C3-H
	4.3	Exterior environment (corrosivity category)	-	C3-H
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

¹ All mentioning of IEC 61400-1 refers to IEC 61400-1:2018 Ed4.

² 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.

Subject	ID	Issue	Unit	Value
	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. Precipitation³	12.1	Annual precipitation	mm/yr	1100

³ 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.

Standard Power Curve, Operational mode 1

Air density 1.225 kg/m³

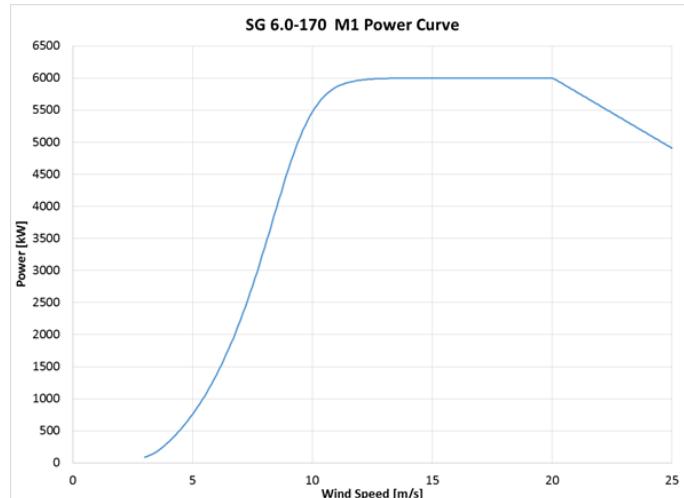
Validity range:

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 [°]	$-2^\circ \leq \beta \leq +2^\circ$
Grid frequency [Hz]	± 0.5 Hz

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

Next table shows the electrical power [kW] as a function of the wind speed [m/s] horizontal referred to the hub height, averaged in ten minutes, for air density = 1.225 kg/m³. The power curve does not include losses in the transformer and high voltage cables. The power curve is for the standard version of the turbine.

SG 6.0-170 Rev 0, Mode 1	
Wind Speed [m/s]	Power [kW]
3.0	89
3.5	176
4.0	325
4.5	520
5.0	756
5.5	1039
6.0	1375
6.5	1772
7.0	2232
7.5	2760
8.0	3350
8.5	3976
9.0	4582
9.5	5097
10.0	5476
10.5	5720
11.0	5861
11.5	5934
12.0	5970
12.5	5987
13.0	5994
13.5	5998
14.0	5999
14.5	6000
15.0	6000
15.5	6000
16.0	6000
16.5	6000
17.0	6000



17.5	6000
18.0	6000
18.5	6000
19.0	6000
19.5	6000
20.0	6000
20.5	5898
21.0	5788
21.5	5678
22.0	5568
22.5	5458
23.0	5348
23.5	5237
24.0	5128
24.5	5017
25.0	4907

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	10.0	
<i>Weibull K</i>	1.5	12456	14777	16985	19045	20932	22633	24143	25463	26597	27556	28349
	2.0	11420	14213	16981	19646	22160	24492	26628	28557	30276	31783	33079
	2.5	10324	13350	16477	19574	22546	25330	27893	30223	32319	34188	35836

Annual Production [MWh] SG 6.0-170 Rev 0, Mode 1 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/m³

Standard Ct Curve, Operational mode 1

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 [°]	$-2^\circ \leq \beta \leq +2^\circ$
Grid frequency [Hz]	$\pm 0.5 \text{ Hz}$

Other considerations: Clean rotor blades, 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:

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

where

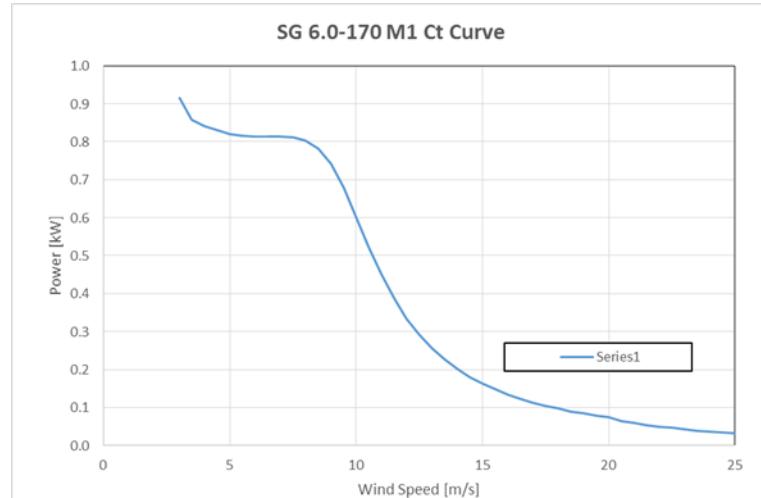
F = Rotor force [N]

ad = Air density [kg/m^3]

w = Wind speed [m/s]

A = Swept area of rotor [m^2]

SG 6.0-170 Rev 0, Mode 1	
Wind Speed [m/s]	C_t [-]
3.0	0.914
3.5	0.859
4.0	0.841
4.5	0.830
5.0	0.821
5.5	0.816
6.0	0.814
6.5	0.813
7.0	0.813
7.5	0.811
8.0	0.803
8.5	0.783
9.0	0.742
9.5	0.679
10.0	0.602
10.5	0.523
11.0	0.450
11.5	0.387
12.0	0.334
12.5	0.291
13.0	0.256
13.5	0.227
14.0	0.202
14.5	0.181



15.0	0.163
15.5	0.148
16.0	0.134
16.5	0.123
17.0	0.113
17.5	0.104
18.0	0.097
18.5	0.090
19.0	0.084
19.5	0.079
20.0	0.075
20.5	0.064
21.0	0.059
21.5	0.054
22.0	0.050
22.5	0.046
23.0	0.043
23.5	0.039
24.0	0.037
24.5	0.034
25.0	0.032

Power Curve, Air density, Operational mode 1

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 $\beta [^\circ]$	$-2^\circ \leq \beta \leq +2^\circ$
Grid frequency [Hz]	$\pm 0.5 \text{ Hz}$

Other considerations: Clean rotor blades, 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 from 1.06 kg/m^3 to 1.27 kg/m^3 . The power curve does not include losses in the transformer and high voltage cables.

$P [\text{kW}]$	Air Density [kg/m^3]								
	1.225	1.06	1.09	1.12	1.15	1.18	1.21	1.24	1.27
3.0	89	75	77	80	82	85	87	90	93
3.5	176	143	149	155	161	167	173	179	185
4.0	325	269	279	289	300	310	320	330	341
4.5	520	437	452	467	482	497	512	527	543
5.0	756	642	663	684	704	725	746	767	787
5.5	1039	887	915	942	970	998	1025	1053	1080
6.0	1375	1178	1214	1250	1286	1322	1357	1393	1429
6.5	1772	1521	1567	1612	1658	1703	1749	1794	1840
7.0	2232	1920	1977	2034	2091	2147	2204	2261	2317
7.5	2760	2378	2448	2517	2587	2656	2726	2795	2864
8.0	3350	2893	2976	3060	3143	3226	3309	3391	3473
8.5	3976	3451	3549	3646	3742	3837	3930	4022	4112
9.0	4582	4024	4133	4239	4342	4441	4536	4627	4714
9.5	5097	4570	4680	4784	4881	4973	5057	5135	5207
10.0	5476	5042	5140	5230	5310	5382	5447	5504	5556
10.5	5720	5407	5483	5551	5608	5658	5701	5738	5770
11.0	5861	5659	5712	5756	5793	5824	5850	5871	5889
11.5	5934	5816	5849	5876	5897	5914	5928	5940	5949
12.0	5970	5906	5925	5940	5951	5960	5967	5973	5977
12.5	5987	5954	5964	5972	5977	5982	5985	5988	5990
13.0	5994	5978	5983	5987	5990	5992	5994	5995	5996
13.5	5998	5990	5992	5994	5995	5996	5997	5998	5998
14.0	5999	5995	5996	5997	5998	5998	5999	5999	5999
14.5	6000	5998	5998	5999	5999	5999	5999	6000	6000
15.0	6000	5999	5999	5999	6000	6000	6000	6000	6000
15.5	6000	6000	6000	6000	6000	6000	6000	6000	6000
16.0	6000	6000	6000	6000	6000	6000	6000	6000	6000
16.5	6000	6000	6000	6000	6000	6000	6000	6000	6000
17.0	6000	6000	6000	6000	6000	6000	6000	6000	6000

17.5	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
18.0	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
18.5	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
19.0	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
19.5	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
20.0	6000	6000	6000	6000	6000	6000	6000	6000	6000	6000
20.5	5898	5898	5898	5898	5898	5898	5898	5898	5898	5898
21.0	5788	5788	5788	5788	5788	5788	5788	5788	5788	5788
21.5	5678	5678	5678	5678	5678	5678	5678	5678	5678	5678
22.0	5568	5568	5568	5568	5568	5568	5568	5568	5568	5568
22.5	5458	5458	5458	5458	5458	5458	5458	5458	5458	5458
23.0	5348	5348	5348	5348	5348	5348	5348	5348	5348	5348
23.5	5237	5237	5237	5237	5237	5237	5237	5237	5237	5237
24.0	5128	5128	5128	5128	5128	5128	5128	5128	5128	5128
24.5	5017	5017	5017	5017	5017	5017	5017	5017	5017	5017
25.0	4907	4907	4907	4907	4907	4907	4907	4907	4907	4907

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

AEP [MWh] @ k=2		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	10.0	
Density [kg/m3]	1.06	10099	12714	15354	17940	20415	22742	24896	26862	28630	30193	31551
	1.09	10350	13002	15670	18274	20759	23089	25241	27201	28961	30514	31861
	1.12	10596	13283	15976	18597	21090	23423	25572	27526	29277	30820	32155
	1.15	10837	13556	16273	18908	21409	23742	25889	27836	29578	31111	32434
	1.18	11073	13824	16562	19210	21717	24051	26193	28134	29866	31389	32701
	1.21	11306	14085	16843	19503	22015	24348	26486	28419	30143	31655	32956
	1.225	11420	14213	16981	19646	22160	24492	26628	28557	30276	31783	33079
	1.24	11534	14341	17117	19788	22303	24635	26768	28694	30408	31910	33200
	1.27	11758	14590	17384	20063	22582	24912	27040	28958	30662	32154	33434

Annual Production [MWh] SG 6.0-170 wind turbine for the Mode 1 standard version, as a function of the annual mean wind speed at hub height and for different air densities considering a Rayleigh wind speed distribution.

Ct Curve, Air Density, Operational mode 1

Air density 1.225 kg/m³

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, 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:

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

where

F = Rotor force [N]

ad = Air density [kg/m³]

w = Wind speed [m/s]

A = Swept area of rotor [m²]

$C_T [-]$	Air Density [kg/m ³]								
	1.225	1.06	1.09	1.12	1.15	1.18	1.21	1.24	1.27
3.0	0.914	0.914	0.914	0.914	0.914	0.914	0.914	0.914	0.914
3.5	0.859	0.859	0.859	0.859	0.859	0.859	0.859	0.859	0.859
4.0	0.841	0.841	0.841	0.841	0.841	0.841	0.841	0.841	0.841
4.5	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830
5.0	0.821	0.821	0.821	0.821	0.821	0.821	0.821	0.821	0.821
5.5	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816	0.816
6.0	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814	0.814
6.5	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813
7.0	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813	0.813
7.5	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811
8.0	0.803	0.804	0.804	0.804	0.804	0.804	0.804	0.803	0.803
8.5	0.783	0.787	0.787	0.787	0.786	0.785	0.784	0.782	0.780
9.0	0.742	0.756	0.755	0.753	0.751	0.748	0.744	0.740	0.734
9.5	0.679	0.709	0.706	0.701	0.696	0.690	0.683	0.675	0.666
10.0	0.602	0.649	0.643	0.635	0.627	0.618	0.608	0.597	0.586
10.5	0.523	0.581	0.572	0.562	0.551	0.540	0.529	0.517	0.505
11.0	0.450	0.512	0.501	0.490	0.479	0.467	0.456	0.444	0.433
11.5	0.387	0.447	0.436	0.425	0.414	0.403	0.392	0.382	0.372
12.0	0.334	0.390	0.379	0.368	0.358	0.348	0.339	0.330	0.322
12.5	0.291	0.340	0.330	0.321	0.312	0.304	0.295	0.288	0.280
13.0	0.256	0.299	0.290	0.282	0.274	0.266	0.259	0.253	0.246

13.5	0.227	0.264	0.256	0.249	0.242	0.236	0.229	0.224	0.218
14.0	0.202	0.234	0.228	0.221	0.215	0.210	0.204	0.199	0.195
14.5	0.181	0.210	0.204	0.198	0.193	0.188	0.183	0.179	0.174
15.0	0.163	0.188	0.183	0.178	0.174	0.169	0.165	0.161	0.157
15.5	0.148	0.170	0.166	0.161	0.157	0.153	0.149	0.146	0.142
16.0	0.134	0.155	0.150	0.146	0.143	0.139	0.136	0.133	0.130
16.5	0.123	0.141	0.137	0.134	0.130	0.127	0.124	0.121	0.119
17.0	0.113	0.130	0.126	0.123	0.120	0.117	0.114	0.111	0.109
17.5	0.104	0.119	0.116	0.113	0.111	0.108	0.105	0.103	0.101
18.0	0.097	0.111	0.108	0.105	0.103	0.100	0.098	0.096	0.093
18.5	0.090	0.103	0.101	0.098	0.096	0.093	0.091	0.089	0.087
19.0	0.084	0.097	0.094	0.092	0.090	0.087	0.085	0.084	0.082
19.5	0.079	0.091	0.088	0.086	0.084	0.082	0.080	0.079	0.077
20.0	0.075	0.086	0.083	0.081	0.079	0.077	0.076	0.074	0.072
20.5	0.064	0.073	0.071	0.069	0.067	0.066	0.064	0.063	0.062
21.0	0.059	0.067	0.065	0.063	0.062	0.061	0.059	0.058	0.057
21.5	0.054	0.061	0.060	0.058	0.057	0.056	0.054	0.053	0.052
22.0	0.050	0.056	0.055	0.054	0.052	0.051	0.050	0.049	0.048
22.5	0.046	0.052	0.051	0.050	0.048	0.047	0.046	0.045	0.045
23.0	0.043	0.048	0.047	0.046	0.045	0.044	0.043	0.042	0.041
23.5	0.039	0.044	0.043	0.042	0.042	0.041	0.040	0.039	0.038
24.0	0.037	0.041	0.040	0.039	0.038	0.038	0.037	0.036	0.036
24.5	0.034	0.038	0.037	0.037	0.036	0.035	0.034	0.034	0.033
25.0	0.032	0.036	0.035	0.034	0.033	0.033	0.032	0.031	0.031

Standard Acoustic Emission, Operational Mode 1

Sound Power Level (L_{WA}):

Sound Power Level warranted according to IEC 61400-11 ed. 3.1 is given in table below.

A measurement uncertainty margin corresponding to 1.5 dB must be considered when demonstrating compliance with given Sound Power Level.

SG 6.0-170	
Wind Speed [m/s]	LW [dB(A)]
3.0	92.0
3.5	92.0
4.0	92.0
4.5	92.2
5.0	94.5
5.5	96.5
6.0	98.4
6.5	100.2
7.0	101.8
7.5	103.3
8.0	104.7
8.5	105.5
9.0	105.5
9.5	105.5
10.0	105.5
10.5	105.5
11.0	105.5
11.5	105.5
12.0	105.5
12.5	105.5
13.0	105.5
13.5	105.5
14.0	105.5
14.5	105.5
15.0	105.5
15.5	105.5
16.0	105.5
16.5	105.5
17.0	105.5
17.5	105.5
18.0	105.5
18.5	105.5
19.0	105.5
19.5	105.5

20.0	105.5
20.5	105.5
21.0	105.5
21.5	105.5
22.0	105.5
22.5	105.5
23.0	105.5
23.5	105.5
24.0	105.5
24.5	105.5
25.0	105.5

Sound Power Level included in the present document correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

Noise Reduction System (NRS) operational modes

The Noise Reduction System NRS is an optional module available with the basic SCADA configuration and it therefore requires the presence of a SGRE SCADA system to work.

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. This allows wind farms to be located close to urban areas, limiting the environmental impact that they imply.

Noise control is achieved through reducing the active power and rotational speed of the wind turbine. This reduction is dependent on the wind speed:

The task of the Noise Reduction System is to control 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.

In order to do this, the SCADA control has to consider the wind speed of each turbine, its direction, and a configured schedule/calendar.

There are 7 low noise modes available, besides the full operation one. Noise levels corresponding to each mode are the following:

Mode:	M2	M3	M4	M5	M6	M7
Sound Power Level [dB(A)]	104.5	103.0	102.0	101.0	100.0	99.0

Sound Power Level included in the present document correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

Depending on the type of tower selected, some of the low noise modes defined above may not be compatible. Low noise modes compatibility vs tower designs will be analyzed upon request.

Next table presents the power production as a function of the horizontal wind speed measured at hub height for different noise reduction mode settings.

P [kW]	Low Noise Operation Mode					
Wind Speed [m/s]	M2	M3	M4	M5	M6	M7
3.0	89	88	89	89	89	89
3.5	176	175	176	176	176	176
4.0	325	325	325	325	325	325
4.5	520	519	520	520	520	520
5.0	756	756	756	756	756	756
5.5	1038	1038	1038	1038	1038	1038
6.0	1373	1373	1373	1373	1372	1369
6.5	1768	1768	1768	1764	1754	1740
7.0	2227	2222	2218	2202	2167	2125
7.5	2749	2722	2708	2660	2582	2494
8.0	3316	3238	3207	3109	2976	2817
8.5	3893	3733	3677	3519	3328	3073
9.0	4430	4171	4087	3871	3629	3260
9.5	4884	4528	4417	4160	3876	3384
10.0	5231	4795	4665	4385	4073	3463
10.5	5470	4979	4840	4553	4224	3514
11.0	5621	5096	4955	4673	4335	3547
11.5	5708	5164	5028	4753	4410	3568
12.0	5754	5202	5070	4804	4458	3582
12.5	5778	5221	5094	4834	4487	3590
13.0	5790	5231	5107	4851	4503	3595
13.5	5795	5236	5114	4861	4511	3597
14.0	5798	5238	5117	4865	4516	3599
14.5	5799	5239	5119	4868	4518	3599
15.0	5800	5240	5119	4869	4519	3600
15.5	5800	5240	5120	4869	4520	3600
16.0	5800	5240	5120	4870	4520	3600
16.5	5800	5240	5120	4870	4520	3600
17.0	5800	5240	5120	4870	4520	3600
17.5	5800	5240	5120	4870	4520	3600
18.0	5800	5240	5120	4870	4520	3600
18.5	5800	5240	5120	4870	4520	3600
19.0	5800	5240	5120	4870	4520	3600
19.5	5800	5240	5120	4870	4520	3600
20.0	5800	5240	5120	4870	4520	3600
20.5	5721	5208	5105	4870	4520	3600
21.0	5637	5172	5081	4870	4520	3600
21.5	5553	5137	5057	4870	4520	3600
22.0	5469	5101	5033	4870	4520	3600
22.5	5385	5066	5009	4870	4520	3600
23.0	5301	5030	4985	4870	4520	3600
23.5	5217	4995	4961	4870	4520	3600
24.0	5134	4959	4936	4870	4520	3600
24.5	5051	4924	4912	4870	4520	3600
25.0	4967	4888	4888	4870	4520	3600

Next table presents the Ct as a function of the horizontal wind speed measured at hub height for different noise reduction mode settings. The calculated Ct curve data are valid for clean rotor blades, substantially horizontal, undisturbed air flow, normal turbulence intensity and normal wind shear.

Ct [-]	Low Noise Operation Mode					
Wind Speed [m/s]	M2	M3	M4	M5	M6	M7
3.0	0.953	0.963	0.953	0.953	0.953	0.953
3.5	0.880	0.886	0.880	0.880	0.880	0.880
4.0	0.847	0.850	0.847	0.847	0.847	0.847
4.5	0.828	0.829	0.828	0.828	0.828	0.828
5.0	0.824	0.824	0.824	0.824	0.824	0.824
5.5	0.828	0.828	0.828	0.828	0.827	0.825
6.0	0.833	0.833	0.832	0.830	0.824	0.815
6.5	0.836	0.833	0.830	0.822	0.803	0.784
7.0	0.835	0.822	0.815	0.795	0.762	0.732
7.5	0.825	0.795	0.782	0.750	0.706	0.666
8.0	0.799	0.750	0.734	0.691	0.641	0.593
8.5	0.754	0.691	0.674	0.626	0.575	0.519
9.0	0.694	0.625	0.606	0.559	0.510	0.448
9.5	0.625	0.556	0.538	0.494	0.451	0.385
10.0	0.553	0.489	0.472	0.434	0.396	0.330
10.5	0.484	0.427	0.412	0.381	0.348	0.285
11.0	0.420	0.371	0.359	0.334	0.306	0.247
11.5	0.365	0.323	0.313	0.293	0.270	0.215
12.0	0.318	0.283	0.274	0.258	0.238	0.189
12.5	0.278	0.248	0.241	0.228	0.210	0.167
13.0	0.245	0.219	0.213	0.202	0.186	0.148
13.5	0.217	0.195	0.190	0.180	0.166	0.132
14.0	0.194	0.174	0.170	0.161	0.149	0.119
14.5	0.174	0.156	0.152	0.145	0.134	0.107
15.0	0.157	0.141	0.138	0.131	0.121	0.097
15.5	0.142	0.128	0.125	0.118	0.110	0.088
16.0	0.129	0.116	0.114	0.108	0.100	0.081
16.5	0.118	0.106	0.104	0.099	0.092	0.074
17.0	0.109	0.098	0.096	0.091	0.084	0.068
17.5	0.100	0.091	0.088	0.084	0.078	0.063
18.0	0.093	0.084	0.082	0.078	0.073	0.059
18.5	0.087	0.078	0.077	0.073	0.068	0.055
19.0	0.081	0.073	0.072	0.068	0.064	0.052
19.5	0.076	0.069	0.068	0.064	0.060	0.049
20.0	0.072	0.065	0.064	0.061	0.056	0.046
20.5	0.062	0.056	0.055	0.053	0.049	0.040
21.0	0.057	0.052	0.052	0.049	0.046	0.038
21.5	0.053	0.049	0.048	0.046	0.043	0.036
22.0	0.049	0.046	0.045	0.044	0.041	0.034
22.5	0.045	0.043	0.042	0.041	0.038	0.032
23.0	0.042	0.040	0.040	0.039	0.036	0.030
23.5	0.039	0.038	0.037	0.037	0.034	0.029
24.0	0.037	0.035	0.035	0.035	0.033	0.027
24.5	0.034	0.033	0.033	0.033	0.031	0.026
25.0	0.032	0.032	0.032	0.031	0.029	0.025

The table below contains the noise levels as a function of the horizontal wind speed measured at hub height for different noise reduction mode settings.

Noise values included in the present document correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

Sound Power [dB(A)]	Low Noise Operation Mode					
	M2	M3	M4	M5	M6	M7
Wind Speed [m/s]						
3.0	92.0	92.0	92.0	92.0	92.0	92.0
4.0	92.0	92.0	92.0	92.0	92.0	92.0
5.0	94.5	94.5	94.5	94.5	94.5	94.5
6.0	98.4	98.4	98.4	98.4	98.4	98.4
7.0	101.8	101.8	101.8	101.0	100.0	99.0
8.0	104.5	103.0	102.0	101.0	100.0	99.0
9.0	104.5	103.0	102.0	101.0	100.0	99.0
10.0	104.5	103.0	102.0	101.0	100.0	99.0
11.0	104.5	103.0	102.0	101.0	100.0	99.0
12.0	104.5	103.0	102.0	101.0	100.0	99.0
13.0	104.5	103.0	102.0	101.0	100.0	99.0
Up to cut-out	104.5	103.0	102.0	101.0	100.0	99.0

Sound Power Level included in the present document correspond to the wind turbine configuration equipped with noise reduction add-ons attached to the blade.

Electrical Specifications

Nominal output and grid conditions

Nominal power	6000 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.....	6150 kW

Nominal speed	1120 rpm-6p (50Hz)
	1344 rpm-6p (60Hz)

Generator Protection

Insulation class	Stator F/H Rotor F/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
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Grid Requirements

Nominal grid frequency.....	50 or 60 Hz
Minimum voltage.....	85 % of nominal
Maximum voltage.....	113 % of nominal
Minimum frequency	94 % of nominal
Maximum frequency	106 % of nominal
Maximum voltage imbalance (negative sequence of component voltage)	≤5 %
Max short circuit level at controller's grid	
Terminals (690 V)	67 kA

Power Consumption from Grid (approximately)

At stand-by, No yawing.....	10 kW
At stand-by, yawing	41 kW

Controller back-up

UPS Controller system	Online UPS, Li battery
Back-up time.....	1 min
Back-up time Scada.....	24 h

Transformer Requirements

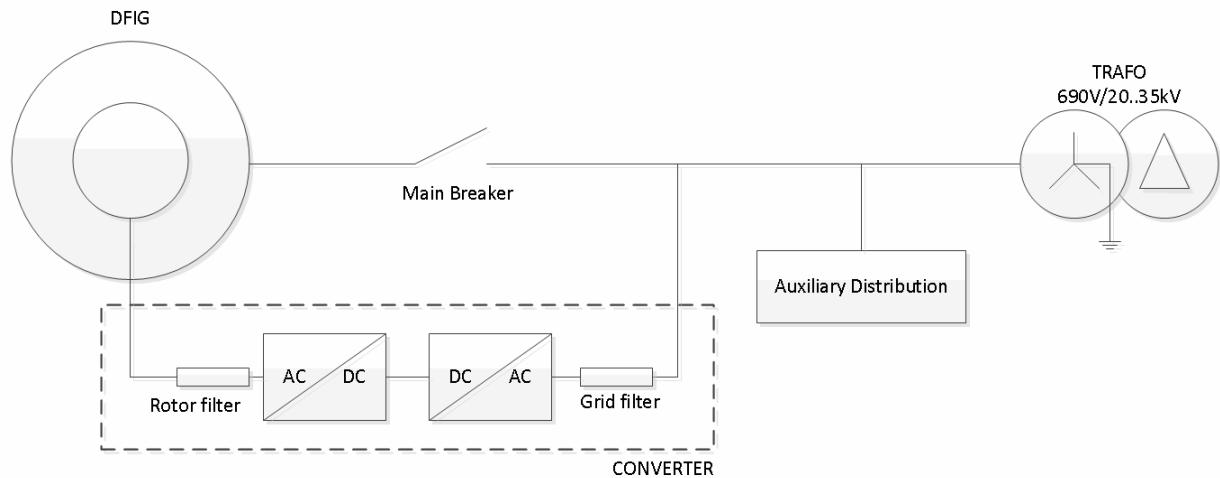
Transformer impedance requirement.....	8.0 % - 10.5%
Secondary voltage	690 V
Vector group	Dyn 11 or Dyn 1 (star point earthed)

Earthing Requirements

Earthing system	Acc. to IEC62305-3 ED 1.0:2006
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

All data are subject to tolerances in accordance with IEC.

Simplified Single Line Diagram



Transformer Specifications ECO 30 kV*

Transformer

Type	Liquid type
Nominal power	7200 kVA at nominal voltage +/-10 %
Nominal voltage	33/0.69 kV
Frequency	50 Hz
Transformer impedance	10.6%
Loss ($P_0 / P_{n120^\circ\text{C}}$)	3.5/113.5 kW
Vector group	Dyn11
Offload tap changer	+/- 2 x 2.5%
Standard	IEC 60076 ECO Design Directive

Transformer Cooling

Cooling type.....	KFWF
Liquid inside transformer...	K-class liquid
Cooling liquid at heat exchanger	Gly santin

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 must be connected to earth
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All data are subject to tolerances in accordance with IEC.

*Example for an ECO 34.5 kV transformer. For other Medium Voltage transformers, consult with SGRE

Switchgear Specifications

The switchgear will be chosen as factory-assembled, type-tested, and maintenance-free medium-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 medium 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 protection relay is a self-powered overcurrent protection relay that does not require external auxiliary voltage supply. 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 feeders⁴; one circuit breaker feeder for the wind turbine transformer also with earthing switch and one or more grid cable feeders⁵ 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.

⁴ Up to four feeders.

⁵ SGRE to be contacted for possible feeder configurations of circuit breaker and grid feeder combinations.

The switchgear is located below the tower structure. 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. Depending on the cable termination kit, up to three grid cable sets can be connected in this cable compartment.

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.

Technical Data for Switchgear

Switchgear		Circuit breaker feeder	
Make	TBD	Rated current, Cubicle	630 A
Type	TBD	Rated current circuit breaker	630 A
Rated voltage	10,5-36 kV	Short time withstand current	20 kA/1s
Operating voltage	10,5-35 kV (Um 40,5kV)	Short circuit making current	50 kA/1s
Rated current	630 A	Short circuit breaking current	20 kA/1s
Short time withstand current	20 kA/1s	Three position switch	Closed, open, earthed
Peak withstand current	50 kA	Switch mechanism	Spring operated
Power frequency withstand voltage	70 kV	Tripping mechanism	Stored energy
Lightning withstand voltage	170 kV		
Insulating medium	SF ₆	Control	Local
Switching medium	Vacuum	Coil for external trip	24 V DC
Consist of	2/3/4 panels	Voltage detection system	Capacitive
Grid cable feeder	Load break switch		
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 FLR 20 kA 1s		
Pressure relief	Upwards	Interface- MV Cables	630 A bushings type C M16
Standard	IEC 62271	Grid cable feeder	Max 3 feeder cables
Temperature range	-25°C to +45°C		
Grid cable feeder		Cable entry	From bottom
Rated current, Cubicle	630 A	Cable clamp size (cable outer diameter) ⁶	26 - 38mm
Rated current, load breaker	630 A		36 - 52mm
Short time withstand current	20 kA/1s		50 – 75mm
Short circuit making current	50 kA/1s	Circuit breaker feeder	630 A bushings type C M16
Three position switch	Closed, open, earthed	Cable entry	From bottom
Switch mechanism	Spring operated		
Control	Local	Interface to turbine control	
Voltage detection system	Capacitive	Breaker status	1 NO contact
		SF ₆ supervision	1 NO contact
		External trip	24 V DC

Siemens Gamesa and its affiliates reserve the right to change the above specifications without prior notice. All data are subject to tolerances in accordance with IEC.

⁶ Cable clamps are not part of switchgear delivery.

Preliminary Foundation Loads

Detailed information about foundation loads will be available upon request.

Tower Dimensions

SG 6.0-170 is offered with a an extensive tower portfolio ranging from 100m-165m. All the towers are designed in compliance with local logistics requirements.

Information about catalogue tower heights will be available upon request.

Foundation Design

Detailed information about foundation loads will be available upon request

Preliminary Grid Performance Specification, 50 Hz

General

This document describes the grid performance of the SG 6.0-170, 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 are based on the assumption 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.

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**. Lower voltage limits for SG 6.0-170, 50 Hz wind turbine in the range of 0-70 seconds. The nominal voltage is 690 V (i.e. 1 p.u.)..

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 in PSS/E. This model is a reduced order model, suitable for balanced simulations with time steps between 4-10 ms.

The standard voltage limits for the SG 6.0-170, 50 Hz wind turbine are presented in **Figure 1**. Lower voltage limits for SG 6.0-170, 50 Hz wind turbine in the range of 0-70 seconds. The nominal voltage is 690 V (i.e. 1 p.u.)..

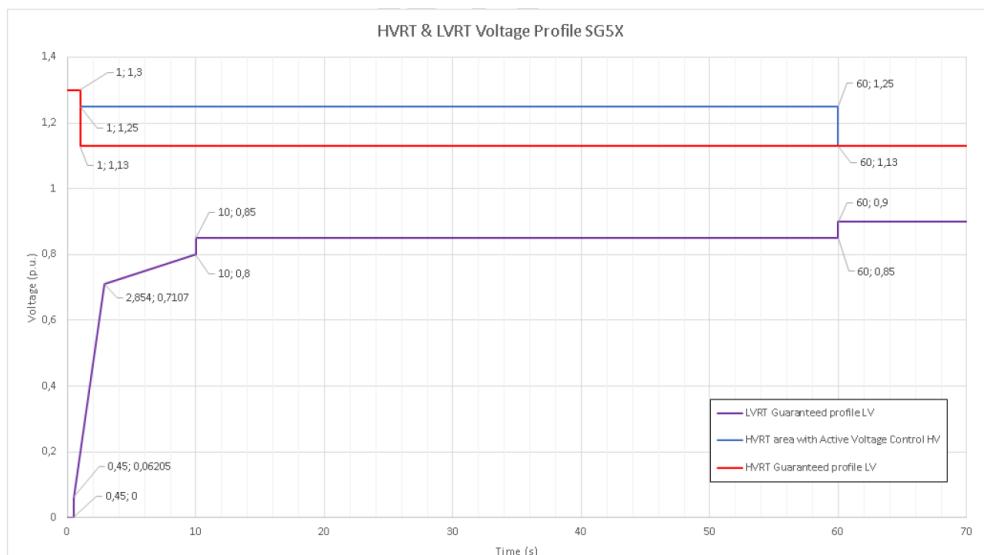


Figure 1. Lower voltage limits for SG 6.0-170, 50 Hz wind turbine in the range of 0-70 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

Power Factor (Reactive Power) Capability

The wind turbine is able to operate in a wide power factor range at the low voltage side of the wind turbine transformer. See the Reactive Power capability chapter for more details. The control mode for the wind turbine is with reactive power set-points.

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.

Frequency Capability

The wind turbine is able to operate in the frequency range between 47 Hz and 53 Hz.

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 60ms. The wind turbine's target voltage shall stay between 95% and 105% in order to support the best possible performance by staying within the operation limits.

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.

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

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.

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.

All data are subject to tolerances in accordance with IEC.

Preliminary Grid Performance Specification, 60 Hz

General

This document describes the grid performance of the SG 6.0-170, 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 are based on the assumption 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.

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 2**. Lower voltage limits for SG 6.0-170, 60 Hz wind turbine in the range of 0-70 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

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 in PSS/E. This model is a reduced order model, suitable for balanced simulations with time steps between 4-10 ms.

The standard voltage limits for the SG 6.0-170, 60 Hz wind turbine are presented in **Figure 2**. Lower voltage limits for SG 6.0-170, 60 Hz wind turbine in the range of 0-70 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

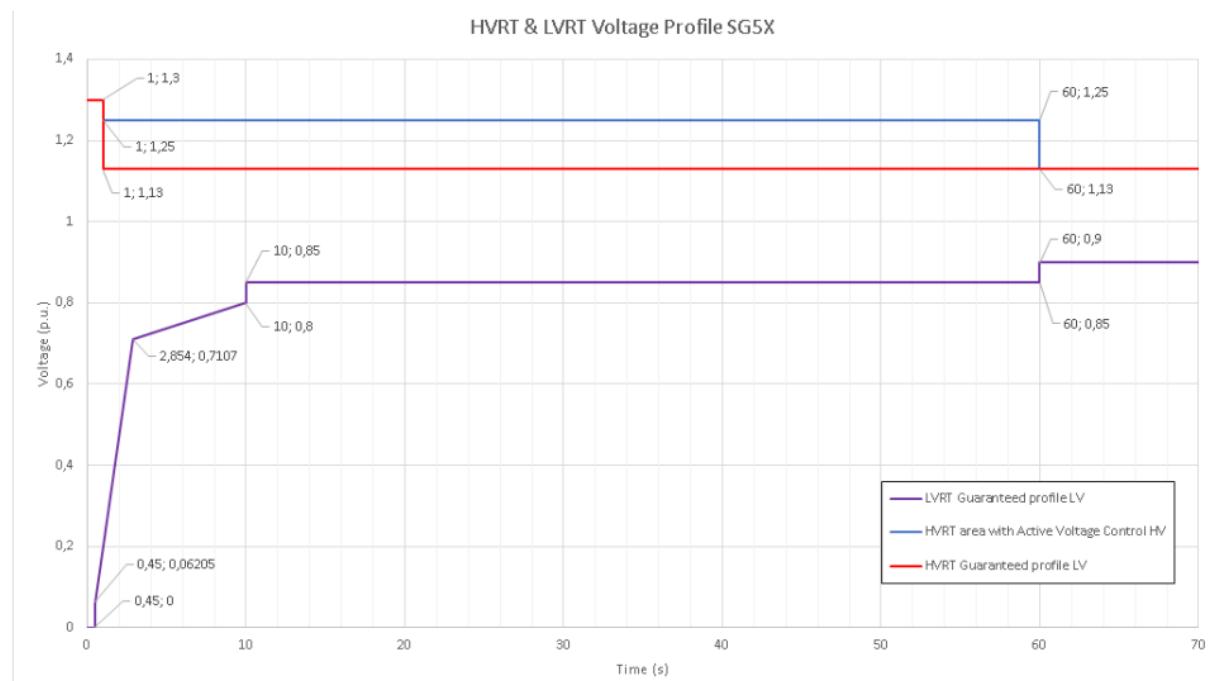


Figure 2. Lower voltage limits for SG 6.0-170, 60 Hz wind turbine in the range of 0-70 seconds. The nominal voltage is 690 V (i.e. 1 p.u.).

Power Factor (Reactive Power) Capability

The wind turbine is able to operate in a wide power factor range at the low voltage side of the wind turbine transformer. See the Reactive Power capability chapter for more details. The control mode for the wind turbine is with reactive power set-points

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.

Frequency Capability

The wind turbine is able to operate in the frequency range between 56.4 Hz and 63.6 Hz.

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 60ms. The wind turbine's target voltage shall stay between 95% and 105% in order to support the best possible performance by staying within the operation limits

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.

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

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.

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.

All data are subject to tolerances in accordance with IEC.

Reactive Power Capability, 50 Hz

General

This document describes the reactive power capability of SG 6.0-170, 50 Hz wind turbines during active power production. SG 6.0-170 wind 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 and grid conditions.

Between others, the Reactive Power Capability at a given Operating Conditions depends on existing Active Power, internal temperature of WTG 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, in order to provide the possibility of maximizing the Capabilities in favorable grid and site conditions.

Reactive Power Capability Curves

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

Figure 1 and 2 show the reactive power capability depending on the generated Active Power at LV terminals, at various voltages between 0.85 p.u. and 1.12 p.u. at the LV terminals. The reference external temperature is set to maximum. Capabilities when reducing ambient temperatures increase.

Between voltages of +112% and +113%, as well as between 85% and 86%, Reactive Power Controller enters in Voltage Saturation Mode and will not allow an amount of Reactive Power generation or consumption that would cause a trip due to over or under voltage protections, caused by the own operation of the turbine. These levels are possible to be set.

Figure 3 includes reactive power capability at no wind operating conditions (Q_{wP0}).

The SCADA can send voltage references to the wind turbine in the range of 0.92 p.u. to 1.08 p.u. The wind power plant should be designed to maintain the wind turbine voltage references between 0.95 p.u. and 1.05 p.u. during steady state operation.

The tables and figures assume that the phase voltages are balanced, and that the grid operational frequency and component values are nominal. Unbalanced voltages will decrease the reactive power capability. Component tolerances were not considered in determining curve parameters. Instead, the curves and data are subject to an overall tolerance of $\pm 5\%$ of the rated power.

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.

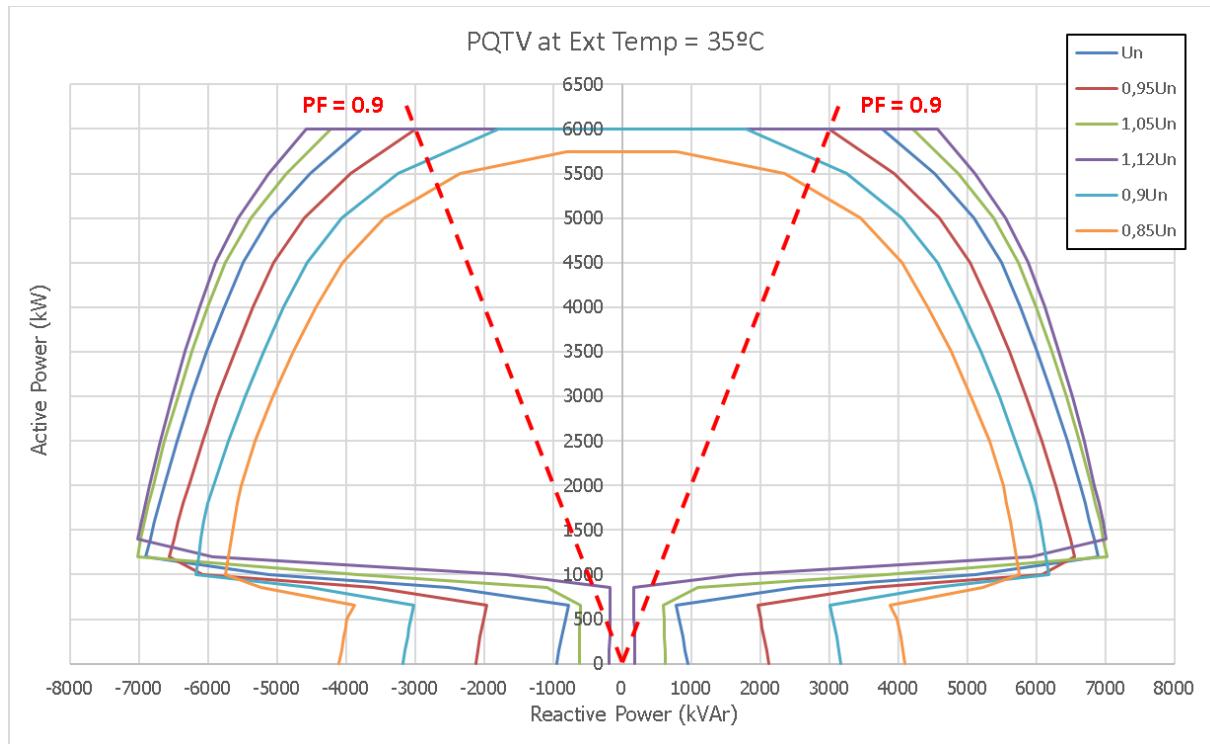


Figure 1: Reactive power capability curves, 50 Hz Wind Turbine, at LV terminals. 35°C External Ambient Temperature

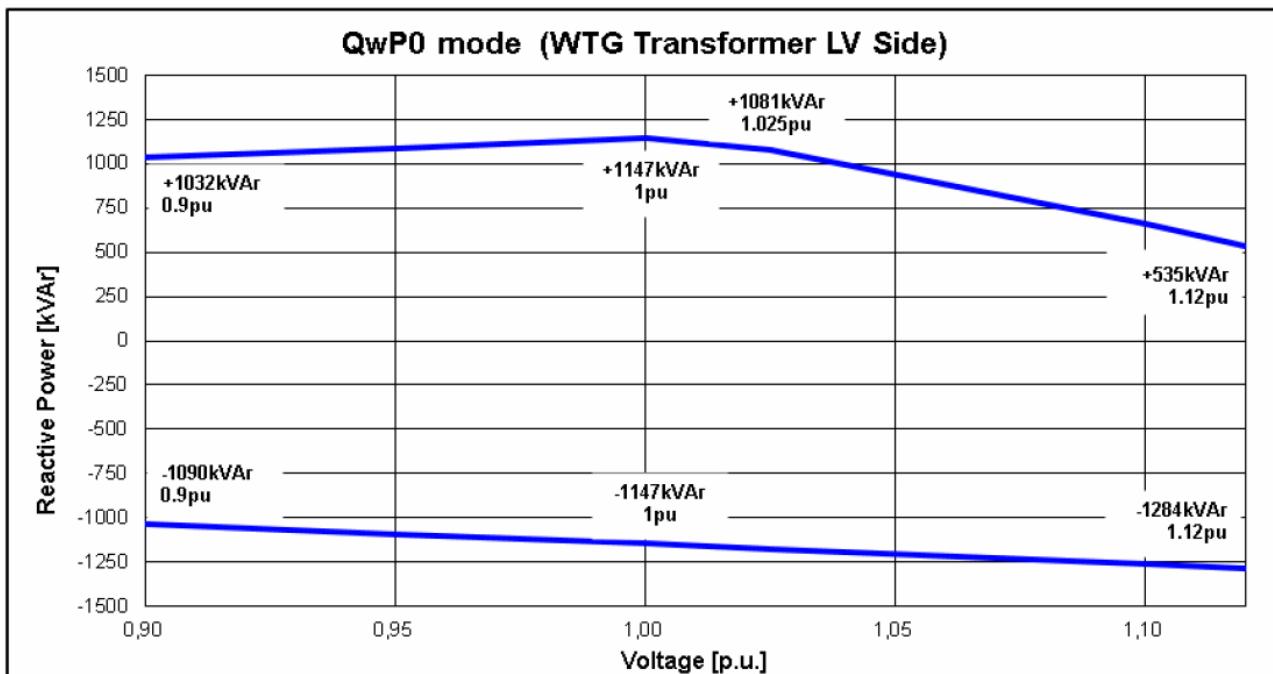


Figure 3: Reactive power capability at no wind (QwP0)

All data are subject to tolerances in accordance with IEC.

Reactive Power Capability, 60 Hz

General

This document describes the reactive power capability of SG 6.0-170, 60 Hz wind turbines during active power production. SG 6.0-170 wind 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 and grid conditions.

Between others, the Reactive Power Capability at a given Operating Conditions depends on existing Active Power, internal temperature of WTG 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.

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The SCADA can send voltage references to the wind turbine in the range of 0.92 p.u. to 1.08 p.u. The wind power plant should be designed to maintain the wind turbine voltage references between 0.95 p.u. and 1.05 p.u. during steady state operation.

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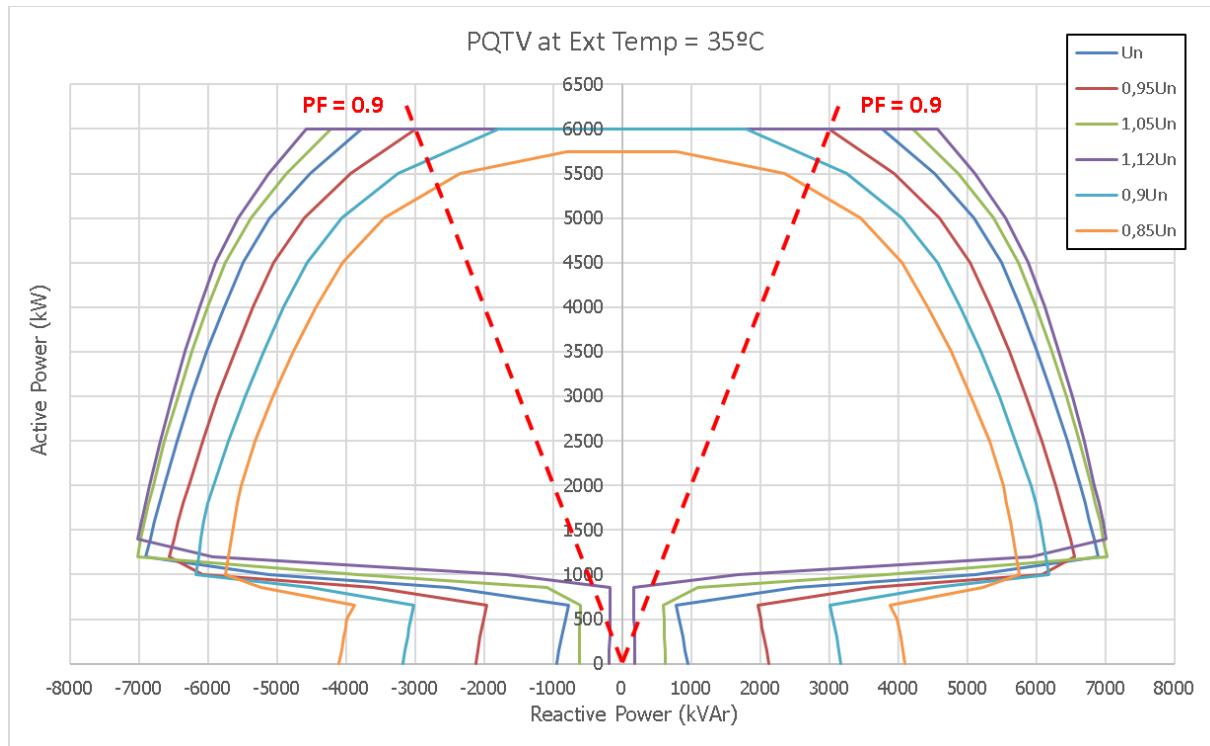


Figure 1: Reactive power capability curves, 60 Hz Wind Turbine, at LV terminals. 35°C External Ambient Temperature

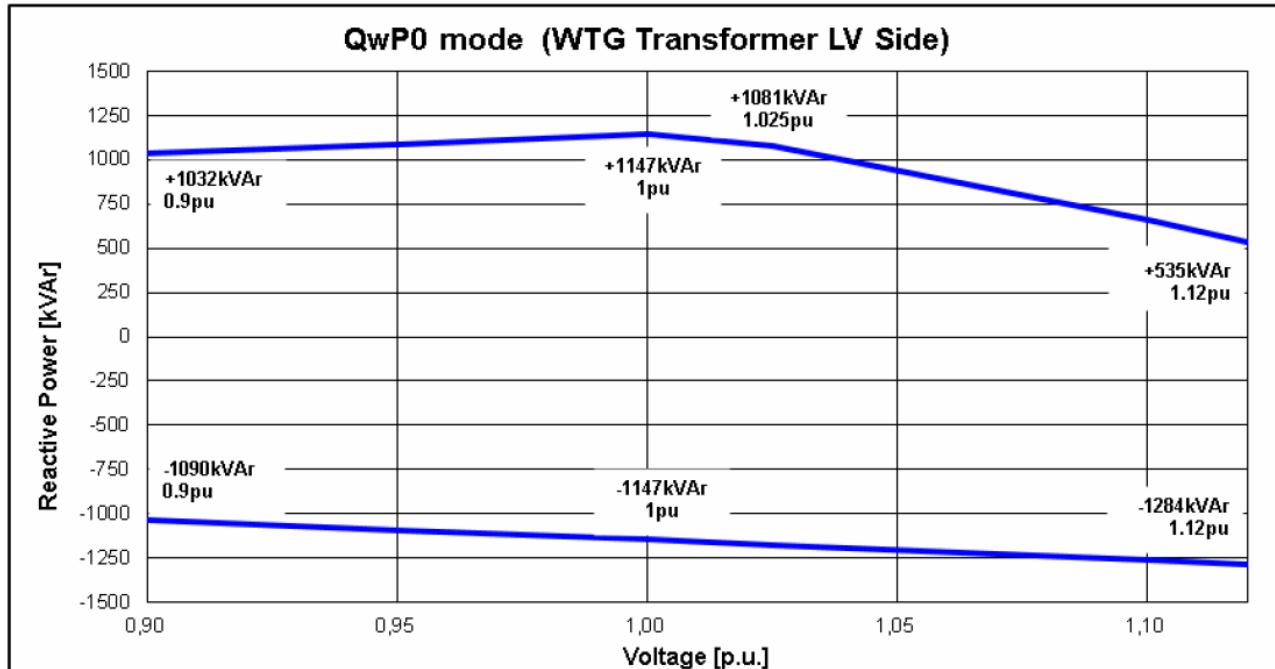


Figure 3: Reactive power capability at no wind (QwP0)

SCADA, System Description

Introduction

This is a general description of the SGRE SCADA System.

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

Main features

The SCADA system has the following main features:

- On-line supervision and control accessible via 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 user names and passwords, and the administrator can assign a user level to each user name for added security.
- Email function can be configured for fast alarm response for both turbine and substation alarms.
- Interface to park pilot functions for enhanced control of the wind farm and for remote regulation, e.g. MW / Voltage / Frequency / Ramp rate.
- 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 compatible interfaces (OPC XML / IEC 60870-5-104 / Modbus TCP).
- Virus Protection Solution.
- Back-up & restore.

Wind turbine hardware

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

A turbine interface computer (STIC) placed at the tower base handles the interface between the STC and the central SCADA server. Data recorded in the turbine is stored here temporary. In the event that communication to the central server is temporarily interrupted data is kept in the STIC and transferred to the SCADA server when possible. The STIC is considered part of the wind turbine.

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.

The supply, installation, and termination of the communication network are carried out by the Employer.

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.

Grid measuring station

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

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

The GMS interfaces to the SGRE SCADA servers and turbines are via a LAN network.

The HPPP 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 GMS components (HPPP / GMS) may be arranged otherwise.

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 a Modbus TCP, IEC 60870-5-104, and OPC XML compatible interfaces are available as an option.

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 Excel via a ODBC connection.

The SGRE SCADA software also serves as user interface to the HPPP functions.

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.

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.

Codes and Standards

The wind turbine is designed and certified with an external certification body according to:

- 1) Operational Document: OD-501, Type Certification Scheme
- 2) OD501-T01 Type Certificate & Provisional Type Certificate template Wind Turbine
- 3) IEC 61400-22:2010 Ed.1, Wind turbines – Part 22: Conformity testing and certification
- 4) EN 61400-1:2018, Ed.4, Wind turbine generator systems Part 1: Safety requirements, (IEC 61400-1:2005, modified)
- 5) IEC 61400-1:2018 Ed.4 Wind turbines – Part 1: Design requirements
- 6) DIBt - Richtlinie für Windenergieanlagen - Oktober 2012, korrigierte Fassung März 2015
- 7) IEC 61400-11:2006, Wind turbine generator systems Part 11: Acoustic noise measurement techniques
- 8) IEC 61400-12:2005, Ed.1, Wind Turbine Generator Systems Part 12: Wind turbines power performance testing
- 9) IEC 61400-13: 2015 Wind Turbine Generator Systems - Part 13: Measurement Of Mechanical Loads
- 10) IEC 61400-23 Ed. 1.0 EN :2014 Wind turbines - Part 23: Full-scale structural testing of rotor blades
- 11) VDI 2230 Blatt 1, 2016, Bolt calculation
- 12) ISO 898-1:2013Mechanical 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
- 13) EN 10029:2010, Hot rolled steel plates 3 mm thick or above - Tolerances on dimensions, shape and mass
- 14) DS/EN 10083:2008, Quenched and tempered steels - Part 1: Technical delivery conditions for special steels (Main shaft)
- 15) DS/EN 1563:2012, Founding - Spheroidal graphite cast irons
- 16) DS/EN 10025-1:2004, Hot rolled products of structural steels - Part 1: General technical delivery conditions
- 17) DS/EN 10025-2:2006, Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels
- 18) DS/EN 10025-3:2004, Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels
- 19) EN 1993-1-8:2005/AC:2009: Eurocode 3: Design of steel structures
- 20) EN 1999 Design of aluminium structures
- 21) ISO/TS 16281:2008 Rolling bearings - Methods for calculating the modified reference rating life for universally loaded bearings
- 22) DIN ISO 281 Rolling bearings - Dynamic load ratings and rating life - Life modification factor aDIN and calculation of the modified rating life
- 23) DIN ISO 76:2006 Rolling bearings - Static load ratings
- 24) ISO/TS 16281:2008 + Cor. 1:2009 Rolling bearings - Methods for calculating the modified reference rating life for universally loaded bearings
- 25) DNV-DS-J102:2010 Design and Manufacture of Wind Turbine Blades, Offshore and Onshore Wind Turbines
- 26) OD-501-2ed.1.0 Conformity Assessment and Certification of wind turbine gearboxes by RECB

-
- 27) [IEC 61400-4:2012](#) Wind turbines -- Part 4: Design requirements for wind turbine gearboxes
 - 28) EN 61000-6-2:2005 Electromagnetic compatibility (EMC) - Part 6-2: Generic standards – Immunity for industrial environments
 - 29) EN 61000-6-4:2007 Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments
 - 30) EN 60204-1:2006 (+correct 2010) Safety of machinery - Electrical equipment of machines - Part 1: General requirements
 - 31) EN 61439-1:2014 Low-voltage switchgear and control gear assemblies. General rules
 - 32) EN 61439-2:2011 Low-voltage switchgear and control gear assemblies. Power switchgear and control gear assemblies
 - 33) [IEC 61400-24 Ed. 1.0](#) (2010) Wind turbines - Part 24: Lightning protection
 - 34) DS/EN 60076 – 16:2018 – Power transformers - Part 16: Transformers for wind turbine applications
 - 35) IEC 61400-21:2008 Wind turbine generator systems - Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines
 - 36) Low Voltage Directive 2014/35/EU
 - 37) EMC Directive 2014/30/EU
 - 38) EN 61000-6-2:2005 Electromagnetic compatibility (EMC) - Part 6-2: Generic standards – Immunity for industrial environments
 - 39) ISO 9001:2015 Quality management systems – Requirements2004/108/EF EMC Directive

Other Performance Features

Siemens Gamesa Renewable Energy (SGRE) offers the following optional performance features for SG 6.0-170 that can optimize your wind farm by boosting performance, enhancing environmental agility, supporting compliance with legal regulation, and supporting grid stability.

High Temperature Derated operational mode (also known as Power Derating due to component temperature)

Ventilation and cooling systems are designed to allow the WTG operation at rated power up to a certain external nominal temperature and a certain altitude. For sites located beyond 1000m above the sea level, the air density reduction affects the turbine components ventilation capacity, reducing the maximum operational temperature at rated power. However, this maximum ambient temperature can be extended by reducing the delivered power.

Considering the individual components requirements in temperatures at different altitude levels, and their dissipated heat at different power limits, several curves power-temperature will be generated. These curves will define the envelopes inside which SG 6.0-170 could operate assuring the integrity of all components.

The control system, considering the defined turbine type, will dynamically adjust the maximum allowed power as a function of component temperature.

Ice Detection System

A default IDS is included in SG 6.0-170. This system is required in order to prevent the turbine operating under non desirable ice conditions that could represent an out-of-design situation with risk for the turbine integrity or H&S.

The default IDS can be improved by application of additional features, described as follows:

- Ice on nacelle sensor (optional kit). Additional sensor is installed to detect ice on nacelle.
- Improved ice on blade detection algorithm (optional, only available when blade de-icing system is installed). It requires additional hardware. It is a more complex ice detection algorithm defined based on ice probability calculation, and it is a valuable complement for improving the blade de-icing system performance.

Noise Reduction System

The Noise Reduction System NRS is an optional module available with the basic SCADA configuration and it therefore requires the existence of a SGRE SCADA system to work.

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. This allows wind farms to be located close to urban areas, limiting the environmental impact that they imply.

Bat Protection System

To support the installation of wind turbines in areas that constitute a natural habitat for bats, SGRE has developed a Bat Protection System. Bats are usually more active at certain times of the night and at certain times of the year, depending on the local habitat and/or migration routes. The purpose of the SGRE Bat Protection System is to monitor the local environmental conditions in order to reduce the risk of impact on bats.

Specific environmental conditions can be monitored by means of dedicated additional sensors: temperature, light, humidity and rainfall. If conditions for the existence of bats are met, the Bat Protection System tool will

request the wind turbines to be paused. As soon as one of the conditions is no longer met, the affected wind turbine will return to its initial status prior to receiving the pause order from the tool, depending on the configured hysteresis values.

The tool does not require all the sensors associated with the conditions to be installed and, depending on each site, the sensors needed will be configured. If there is no sensor for a specific environmental variable, condition is configured as fulfilled.

Additionally, Bat Protection System can be configured to be triggered depending on calendar (day/time), wind speed range or wind direction.

Bird Detection System

The Bird Detection System is a stand-alone system that monitors the wind farm's surrounding air space and detects flying birds in real time. At the same time, it is capable of handling real-time actions related to bird detection, such as warning and deterring birds at risk of colliding with the wind turbines or automatic shutdown of the selected wind turbines.

Preliminary Site roads and Hardstands

SG 6.0-170

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Aim and Scope

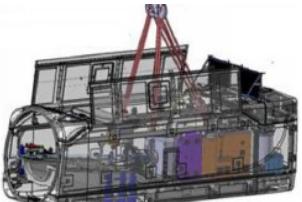
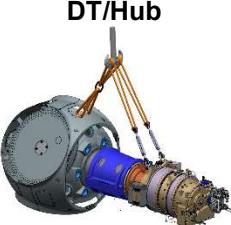
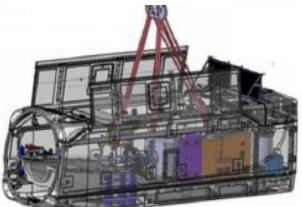
The aim of this specification is to describe the dimensional and compositional characteristics of the roads and hardstands required for assembly and its scope includes all W.F. with:

Product		
Tower	No. of tubular steel section	Blade
T100	6	SG170
T115	5	
T165MB	3	

Strategies		
Tower	STG3	STG4 (SGRE Standard)
T100	✓	✓
T115	✓	✓
T165MB	✓	✓

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.

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

Definition and Acronyms

Definition and Acronyms	Description
SGRE	Siemens Gamesa Renewable Energy
Main crane	Capable of lifting any component to the highest point of the wind turbine.
Auxiliary crane	Used for installing elements at the lower part of the tower.
Retention crane	Supports the main and auxiliary cranes for mounting and unloading components.
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.
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.
NTC	Narrow-Track Crane
WTC	Wide-Track Crane
Pneumatic crane	Crane on truck
Tower crane	Vertical crane
SP	Standard Proctor
MP	Modified Proctor

Description

Roads

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.

Road composition and structure

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

Internal wind farm roads must support a maximum 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 pneumatic cranes with lattice boom.
- 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 pneumatic cranes with lattice boom.
 - 24.5t per axle in the case of pneumatic cranes with telescopic boom
 - 14.7t per axle in the case of auxiliary pneumatic cranes with telescopic boom

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 (see chapter 5 "Quality control" of this procedure) on the material used for the subgrade and for the roadbed, in order to control the compacting of the different layers and ensure that the civil works are correctly executed.

With the trace material, once analyzed, suitable compaction means must be used to find a subgrade of sufficient elasticity modulus value to minimize the thicknesses and quality of the material in the roadbed, thus reducing its financial cost. 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), and in no case should the result be less than $E_{v2} = 60$ MPa. The degree of compaction of the layers of material for the subgrade must ensure a dry density that cannot be less than 95% of that obtained in the PN.

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.

Whenever it is not possible to use some other fill material, in the event of fills consisting of expansive materials (expansive clay, etc.), geotextile materials or similar materials must be laid. If the ground on which the road is laid is also expansive, geotextiles or similar materials must be used.

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 $E_{v2}=80$ 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:

$$E = \frac{\pi \cdot (1 - v^2)}{3} \cdot E_{v2}$$

- E: elasticity module
- v: Poisson's ratio
- E_{v2} : second plate loading test cycle compressibility module

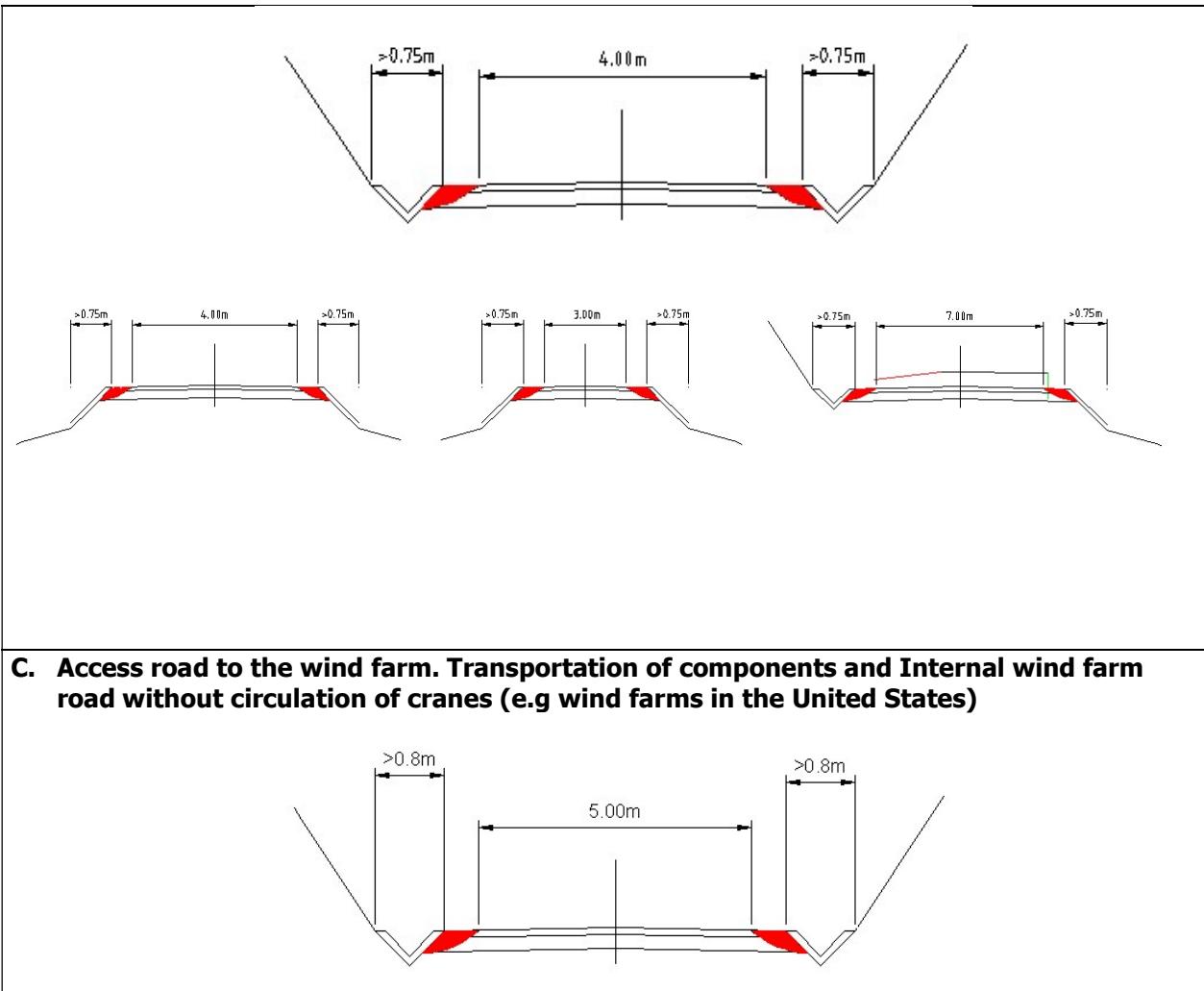
Additionally, remember that the dry density required after compaction for the different types of materials forming the roadbed is 98% of that obtained in the PM test or above.

Road Width

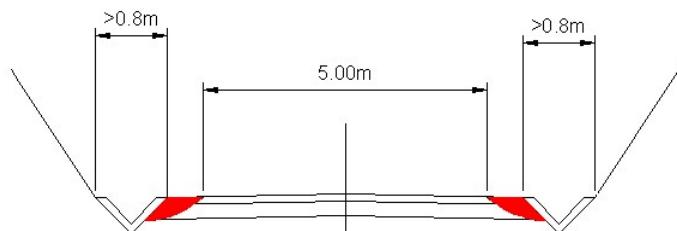
The road width will vary for curves according to the following section "Turning Radii"

Minimum road width	
A. Wind farm access road transportation of components	Usable 4.0m* + 2 x 0.50m free of obstacles
B. Internal wind farm road with crane movement	<p>Pneumatic Crane: Usable 4.0m + 2 x 0.75m free of obstacles</p> <p>WTC:</p> <ul style="list-style-type: none"> • Usable 12 to 14m* • 4m + 3m parallel tread (making 12 to 14 m) <p>NTC: Usable 7m</p>
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)	Usable 5m + 2 x 0.8m free of obstacles
<p>Note:</p> <p>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</p> <p>*Width based on crane model</p>	

A. Wind farm access road Transportation of components
B. Internal wind farm road with crane movement



C. Access road to the wind farm. Transportation of components and Internal wind farm road without circulation of cranes (e.g wind farms in the United States)



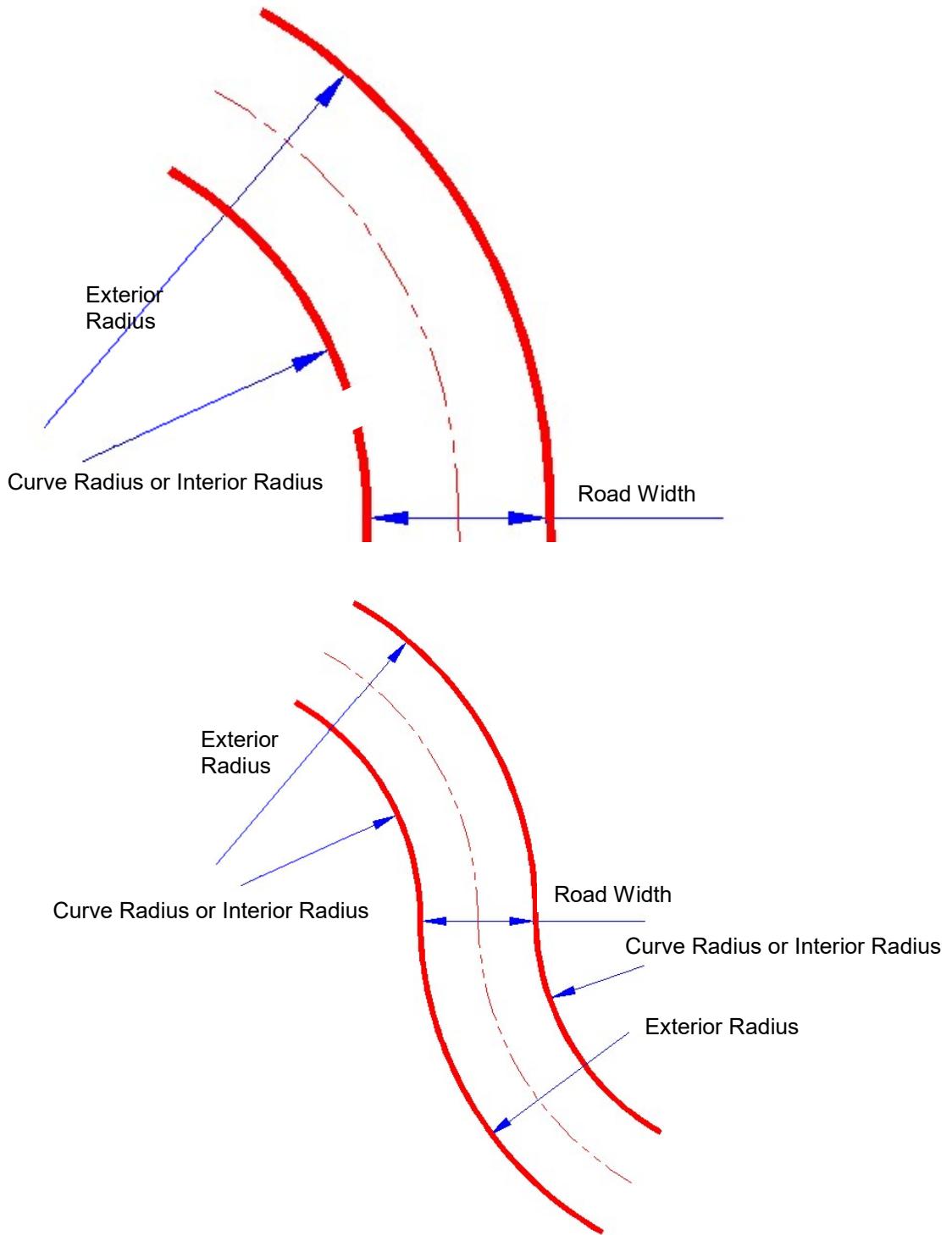
For curves with an interior cleared profile, the inside curb of the curve must be piped or have a maximum depth of 10 cm.

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.

Turning Radii - 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.

The curve radius will be the radius of the alignment curve on the inside of the road



Blade transportation is considered to be a limiting element in the calculation of curve radii.

Where:

- W - Road width
- Es - Exterior shoulder (sweep of the blade free of obstacles)
- Is - Interior shoulder (sweep of the blade free of obstacles)

Inner and outer widening for each curve along the route must be studied as per transport simulation, with the means of transport considered for the project.

Gradients and grade changes

	Longitudinal Gradients (%)				Transversal Gradients (%)	
	Maximum		Minimums		Maximum	Minimum
	Straight section	Curved section	Straight section	Curved section	Straight/curved section	Straight/curved section
A. 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
B. 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						

The transport vehicles used to transport various components of the turbine up to the site must be equipped with self-steering rear axles.

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 has to 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 has to 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.

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

Avoid sudden changes in grade whenever possible. There must be at least 540 kV. The roads must be smooth, removing, as far as possible, any protrusions such as stones, rocks, etc., which could damage the nacelle platform or the tower sections and hinder transportation.

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 works.

Minor transversal drainage work crossing the roads must be supported on a 10 cm thick fill base of H-20 N/mm² concrete. It must also be concreted with lightweight concrete so that the drainage work acts as lost formwork, guaranteeing a minimum covering of 5 cm on the sides and top part of the pipe. Finally, the part on top of the drain will be filled in until it reaches the roadway level with the same material used for the sections of road that do not have drainage. The slope of these pipes must be sufficient to allow for draining, avoiding silting at the inlet but not too much to avoid significant erosion at the outlet.

Experience has shown that continuous passage of transport vehicles over areas filled with existing excavated material usually causes these areas to cave in. The wearing course must be as waterproof as possible (bearing in mind the limitations of the material used), in order to reduce the amount of surface water reaching the roadbed body due to infiltration. Good compaction is therefore essential. To avoid too much water on the roadbed and on the subgrade, a very common problem on wind farm access roads and internal wind farm roads, the upper level of the subgrade must be above the highest foreseeable level of the water table.

Intersection and turning areas

For wind farms with long access roads, intersections will be required approximately every 5 km that are 85 m in length and 5 m in width.

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.

Hardstands

Note:

Hardstand layout considers standard SGRE assembly strategy 4

Hardstand composition and structure

The hardstands will include a crane work area and areas defined as storage areas. In the crane work area, the most important thing is to obtain the correct support for the main crane, therefore the use of gravel is not as critical as on the roads. Gravel must be used where the material used in the hardstand does not allow for finishing to obtain the maximum gradients indicated in this document.

The different parts of the wind turbine are to be located in the storage area to be hoisted by the cranes from the hardstand.

Avoid placing high-power and communications networks across the hardstand. If this cannot be avoided, then the network must be pipelined, and the pipes covered with concrete with a minimum covering of 5 cm.

On hardstand, particularly in the crane work area, the upper level of the subgrade must be above the highest foreseeable level of the water table.

Where expansive material (expansive clay, etc.) is used for fill because no other fill material can be used in areas where water cannot be run off, geotextiles or similar material must be laid. If the ground on which the hardstand lies is expansive, geotextile or similar materials must also be laid.

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 $E_v=120$ MPa. Likewise, the relation between the first and second load cycle must be less than 2.5.

Bearing capacity

Load-Bearing Capacity (kg/cm^2)			
	Crane work area	Component storage area	Boom assembly area
SGRE standard	2	2	2
Without crane mats	3 (T100m) 3 (T115m) 5 (T165m)	2	2

The composition of the crane work area must have a good subgrade $E_v=60$ MPa or above, with a bearing capacity of $2\text{kg}/\text{cm}^2$. A surface of 30 m^2 must be laid, 6 crane mats ($5 \text{ m} \times 1 \text{ m}$) per crane leg or crane chain.

If opting not to use crane mats, the necessary bearing capacity will be $3 \text{ kg}/\text{cm}^2$ for T100m, $3 \text{ kg}/\text{cm}^2$ for 115m, $5 \text{ kg}/\text{cm}^2$ for 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.

The compaction level will be such that the dry density after compaction is 95% SP or higher. Where necessary, a 30 cm layer of artificial aggregate will be applied and compacted to 98% of the MP.

The composition of the storage areas must have a good subgrade (EV2 of 60 MPa or better) with an upper level bearing capacity of at least 2 kg/cm² (approx. 0.2 MPa). The density resulting from compacting must be sufficient so that the subgrade material fulfills bearing specifications. If that is established in met in storage areas, no layer of gravel will be needed.

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.

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

Hardstand gradients

Hardstand gradients (%)			
Crane work area		Component storage area	
Maximum	Minimum	Maximum	Minimum
- 3 (if NTC or Pneumatic)	0.2	2	0.2
- 0.5 (if WTC)			

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.

Hardstand dimensions

Following hardstand dimensions covers tower section off-loading with cranes only. The specification does not consider tower section transport with clamp system (self-off-loading). Use of clamp system doesn't require cranes for off-loading but additional space for maneuvering of trailers to release the tower sections is needed. This will have an impact in hardstand dimensions and must be evaluated and approved project specific.

T 100m Hardstand dimensions (Section 6.1)		
Storage conditions	Middle hardstand (width x length)	End-of-road hardstand (width x length)
Total Storage	<ul style="list-style-type: none"> Main crane and component storage = 43m x 12m + (43m x 75m)/2 Blade storage = 18m x 85m (free of obstacles) Blade fingers (hardstand) = fingers (2 x 3m x 18m) 	<ul style="list-style-type: none"> Main crane and component storage = 43m x 12m + (43m x 75m)/2 Reinforced road part = 4m x 101m Blade storage = 18m x 85m (free of obstacles) Blade fingers (hardstand) = fingers (2 x 3m x 18m)
Partial storage (SGRE standard)	<ul style="list-style-type: none"> Main crane and component storage = 42m x 4m + (42m x 73m)/2 	<ul style="list-style-type: none"> Main crane and component storage = 42m x 4m + (42m x 73m)/2 Reinforced road part = 4m x 91m

	<ul style="list-style-type: none"> • Blade storage = 18m x 85m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m) 	<ul style="list-style-type: none"> • Blade storage = 18m x 85m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m)
Just in time	<ul style="list-style-type: none"> • Main crane = 20m x 31m + (20m x 14.5m)/2 • Component storage = 85m x 5m • Blade storage = 18m x 85 m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m) 	<ul style="list-style-type: none"> • Main crane= 20m x 31m + (20m x 14.5m)/2 • Reinforced road part = 4m x 59.5m • Component storage = + 85m x 5m • Blade storage = 18m x 85m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m)

T 115m Hardstand dimensions (Section 6.2)		
Storage conditions	Middle hardstand (width x length)	End-of-road hardstand (width x length)
Total Storage	<ul style="list-style-type: none"> • Main crane and section storage = 41m x 14m + (41m x 73m)/2 • Component storage = 5m x 85m • Blade storage = 18m x 85 m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m) 	<ul style="list-style-type: none"> • Main crane and section storage = 41m x 14m + (41m x 73m)/2 • Reinforced road part = 4m x 101m • Component storage = 5m x 85m • Blade storage = 18m x 85m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m)
Partial storage (SGRE standard)	<ul style="list-style-type: none"> • Main crane and section storage = 41m x 14m + (41m x 63m)/2 • Component storage = 5m x 85m • Blade storage = 18m x 85 m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m) 	<ul style="list-style-type: none"> • Main crane and section storage = 41m x 14m + (41m x 63m)/2 • Reinforced road part = 4m x 91m • Component storage = 5m x 85m • Blade storage = 18m x 85m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m)
Just in time	<ul style="list-style-type: none"> • Main crane = 20m x 31m + (20m x 14.5m)/2 • Component storage = 85m x 5m • Blade storage = 18m x 85 m (free of obstacles) 	<ul style="list-style-type: none"> • Main Crane = 20m x 31m + (20m x 14.5m)/2 • Reinforced road part= 4m x 59.5m • Component storage = 85m x 5m • Blade storage = 18m x 85m (free of obstacles) • Blade fingers (hardstand) = fingers (2 x 3m x 18m)

T165m MB Hardstand dimensions (Section 6.3)		
Storage conditions	Middle hardstand (width x length)	End-of-road hardstand (width x length)
Partial storage (SGRE standard)	<ul style="list-style-type: none"> Main Crane, concrete and section storage = 38m x 41m Concrete, DT and Hub storage = 9.5m x 9.5m Support Crane (17m x 33m)/2 Component storage 5m x 85m Blade storage = 18m x 85 m (free of obstacles) Blade fingers (hardstand) = fingers (2 x 3m x 18m) 	<ul style="list-style-type: none"> Main Crane, concrete and section storage = 38m x 41m Concrete, DT and Hub storage = 9.5m x 9.5m Support Crane (17m x 33m)/2 Component storage 5m x 85m Blade storage = 18m x 85 m (free of obstacles) Blade fingers (hardstand) = fingers (2 x 3m x 18m)

In all hardstands, 2 additional areas of 12.2 m x 18 m and 12.2 m x 16 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 have two “blade fingers” and these must be leveled and elevated min. 1m over the surrounding terrain to avoid blade touching the ground and be able to operate the blade lifting yoke (clamper).

There must be provided accessible Working Area between the fingers and tip end of the blade. It is necessary to remove any high obstacles and trip hazards within this area to ensure safe operation. Surface of the blade storage area must be leveled with adjoining road where the blades are offloaded from.

If the blade storage area is higher or lower than the adjoining road, this must be approved by Siemens Gamesa as it will have an impact on delivery of 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 maximum distance from the center 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.)

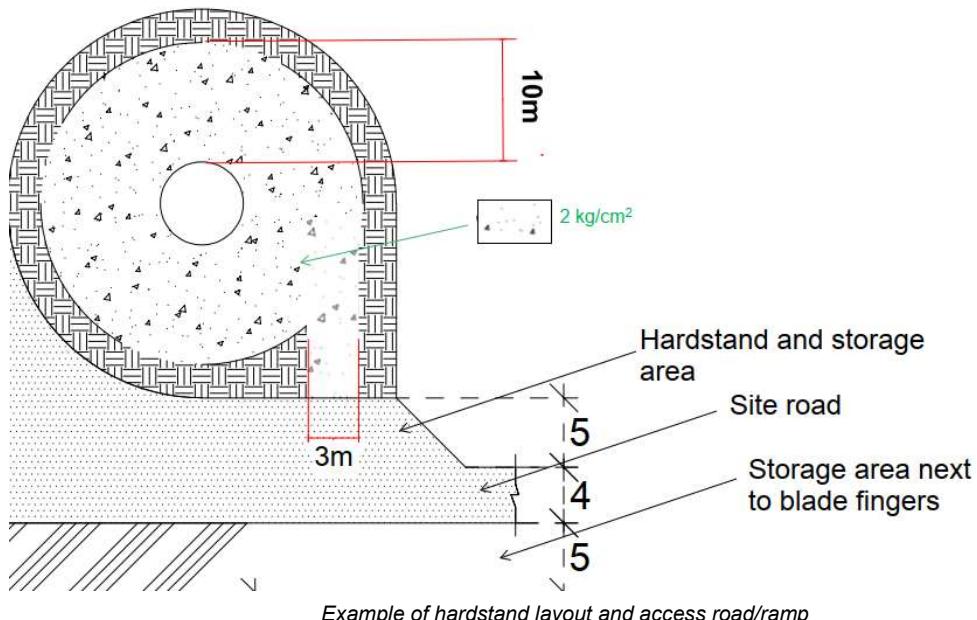
Intermediate hardstand adjacent to the road, but at a different level, must have a separate hardstand entrance and exit. Otherwise it must be considered end-of-road hardstand.
For end-of-road hardstands, the foundation should be at the end of the hardstand, avoiding having the foundation at the entrance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

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

A compacted area around the tower (on top of foundation) need 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.



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

Requirements for assembly the main crane

		T100m	T115m	T165m MB
Pneumatic	Crane	Area for assembly and disassembly on each hardstand and along site road	Area for assembly and disassembly on each hardstand and along site road	Area for assembly and disassembly on each hardstand and along site road
	NGC	Area for assembly and disassembly on	Area for assembly and disassembly on	Area for assembly and disassembly on

	each hardstand and along site road	each hardstand and along site road	each hardstand and along site road
WTC	Assembly area at the beginning and end of the Wind Farm or each branch	Assembly area at the beginning and end of the Wind Farm or each branch	Assembly area at the beginning and end of the Wind Farm or each branch
Dimensions	122m in a straight line x 3m wide	134m in a straight line x 3m wide	177m in a straight line x 3m wide

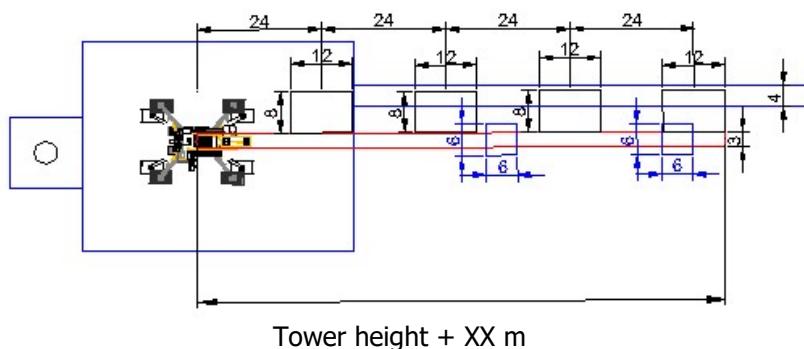
If there are several branches far away from one another, an area must be prepared for assembling and disassembling the boom of the main crane at the beginning and end of each wind farm branch or on each hardstand depending on the crane model to be used.

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

There must be areas without vegetation, flat and compacted with a surface area of 8 m x 12 m, every 24 m along the boom for 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 assembly. This would not be a SGRE standard and a specific study would need to be done.

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

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

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.

Work areas distance limits				
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

(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).
- 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).

Additional documentation

Document to be completed based on the wind farm conditions. This document will present the data for road width, longitudinal and transversal gradients, load-bearing capacity of hardstands and hardstand sizing for each wind turbine and crane model needed for assembly.

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

Work execution control plan

Quality controls must be carried out as per the provisions of the project's quality plan. In countries with their own regulations regarding this matter, the most restrictive will apply.

Where there are no regulations regarding this matter in the country where the wind farm is located, the one indicated below shall apply.

Test required for characterization of materials: Access and service roads		
Underlying earth characterization tests	Standard	Frequency
Grain-size analysis by sifting	ASTM D 422*	Every 500 m of underlying ground type found
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Oxidizable organic matter content	BS 1377*	
Determination of soil moisture by stove drying	ASTM D 2216* // ASTM D 3017/88** (NUCLEAR SYSTEM)	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	
Testing method to determine the CBR index of a soil in laboratory		
Free swell test of a soil in oedometer		
Soluble salt content in soils		
Gypsum content in soils		
Collapse test in soils	ASTM D 5333*	DIN 18134 (or NLT-357)
Compressibility modulus in the second load cycle (EV2) obtained in accordance with load plate test		
Characterization tests of the fill material to be used for subgrade formation: Rock fill	Standard	Frequency
Grain-size analysis by sifting		Per source material and less than 3000 m ³
Stability in water		
Characterization tests of the fill material to be used for subgrade formation: Sand	Standard	Frequency
Grain-size analysis by sifting	ASTM D 422*	For each type of material used in the filling, extraction for each zone and for each type of system compaction.
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Collapse test in soils	ASTM D 5333*	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	
Sand equivalent	ASTM D 2419*	
Los Angeles abrasion factor	ASTM C 131*	
Testing method to determine the CBR index of a soil in laboratory	ASTM D 1883*	
Free swell test of a soil in oedometer	ASTM D2435*	
Soluble salt content in soils		

Gypsum content in soils		
Determination of soil moisture by stove drying	ASTM D 2216* // ASTM D 3017/88** (NUCLEAR SYSTEM)	
Oxidizable organic matter content	BS 1377*	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	1 per hardstand on complete surface
Grain-size analysis by sifting	ASTM D 422*	
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Testing method to determine the CBR index of a soil in laboratory		1 per 10,000 m ³ of material or once a week
Oxidizable organic matter content	BS 1377*	
Surface granular layer characterization tests/Crushed stone	Standard	Frequency
Grain-size analysis by sifting	ASTM D 422*	For each type of material used in the filling, extraction for each zone and for each type of system compaction.
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	
Los Angeles abrasion factor	ASTM C 131*	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	1 per hardstand on complete surface
Grain-size analysis by sifting	ASTM D 422*	1 per 5,000 m ³ of material or every 3 days
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Testing method to determine the CBR index of a soil in laboratory		1 per 10,000 m ³ of material or once a week
Oxidizable organic matter content	BS 1377*	

Test required for characterization of materials: Hardstand		
Underlying earth characterization tests	Standard	Frequency
Grain-size analysis by sifting	ASTM D 422*	Each hardstand position
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Oxidizable organic matter content	BS 1377*	
Determination of soil moisture by stove drying	ASTM D 2216* // ASTM D 3017/88** (NUCLEAR SYSTEM)	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	

Testing method to determine the CBR index of a soil in laboratory		
Free swell test of a soil in oedometer		
Soluble salt content in soils		
Gypsum content in soils		
Collapse test in soils	ASTM D 5333*	
Compressibility modulus in the second load cycle (EV2) obtained in accordance with load plate test	DIN 18134 (or NLT-357)	
Characterization tests of the fill material to be used for subgrade formation: Rockfill	Standard	Frequency
Grain-size analysis by sifting		Per source material and less than 3000 m ³
Stability in water		
Characterization tests of the fill material to be used for subgrade formation: Crushed stone	Standard	Frequency
Grain-size analysis by sifting	ASTM D 422*	For each type of material used in the filling, extraction for each zone and for each type of system compaction.
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Collapse test in soils	ASTM D 5333*	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	
Sand equivalent	ASTM D 2419*	
Los Angeles abrasion factor	ASTM C 131*	
Testing method to determine the CBR index of a soil in laboratory		
Free swell test of a soil in oedometer		
Soluble salt content in soils		
Gypsum content in soils		
Determination of soil moisture by stove drying	ASTM D 2216* // ASTM D 3017/88** (NUCLEAR SYSTEM)	
Oxidizable organic matter content	BS 1377*	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	1 per hardstand on complete surface
Grain-size analysis by sifting	ASTM D 422*	1 per 5,000 m ³ of material or every 3 days
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Testing method to determine the CBR index of a soil in laboratory		1 per 10,000 m ³ of material or once a week
Oxidizable organic matter content	BS 1377*	
Surface granular layer characterization tests	Standard	Frequency
Grain-size analysis by sifting	ASTM D 422*	For each type of material
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	

Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	used in the filling, extraction for each zone and for each type of system compaction.
Los Angeles abrasion factor	ASTM C 131*	
Modified Proctor	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	1 per hardstand on complete surface
Grain-size analysis by sifting	ASTM D 422*	1 per 5,000 m ³ of material or every 3 days
Liquid limit	ASTM D 4318*	
Plastic limit	ASTM D 4318*	
Testing method to determine the CBR index of a soil in laboratory		1 per 10,000 m ³ of material or once a week
Oxidizable organic matter content	BS 1377*	

Test required for building control: Access and service roads

Subgrade building control test	Standard	Frequency
On-site density testing using the nuclear method and/or sandblast method	ASTM D 1557* // BS 1377-4.2* ASTM D 2922/81 ** (NUCLEAR SYSTEM)	5 test per 5000 m ² of layer or once a day
On-site humidity testing using the nuclear method	ASTM D 2216* // ASTM D 3017/88** (NUCLEAR SYSTEM)	
Compressibility modulus in the second load cycle (EV2) obtained in accordance with load plate test	ASTM E 2835	1 every 500 m
Subbase layer execution test		
On-site density testing using the nuclear method and/or sandblast method	ASTM D 3017/88** (NUCLEAR SYSTEM)	5 test per 5000 m ² of layer or once a day
On-site humidity testing using the nuclear method	ASTM D 3017/88** (NUCLEAR SYSTEM)	
Base layer execution test		
On-site density testing using the nuclear method and/or sandblast method	ASTM D 3017/88** (NUCLEAR SYSTEM)	5 test per 5000 m ² of layer or once a day
On-site humidity testing using the nuclear method	ASTM D 3017/88** (NUCLEAR SYSTEM)	
Compressibility modulus in the second load cycle (EV2) obtained in accordance with load plate test	DIN 18134 (OR NLT-357)	1 every 500 m

Test required for building control: Hardstands

Subgrade building control test		
On-site density testing using the nuclear method and/or sandblast method	ASTM D2922** (NUCLEAR SYSTEM)	5 test per 5000 m ² of layer or once a day
On-site humidity testing using the nuclear method	ASTM D 3017/88** (NUCLEAR SYSTEM)	

Compressibility modulus in the second load cycle (EV2) obtained in accordance with load plate test	DIN 18134 (OR NLT-357)	1 per platform on completed surface
Subbase layer execution test		
On-site density testing using the nuclear method and/or sandblast method	ASTM D2922** (NUCLEAR SYSTEM)	5 test per 5000 m ² of layer or once a day
On-site humidity testing using the nuclear method	ASTM D 3017/88** (NUCLEAR SYSTEM)	
Base layer execution test		
On-site density testing using the nuclear method and/or sandblast method	ASTM D 3017/88** (NUCLEAR SYSTEM)	5 test per 5000 m ² of layer or once a day
On-site humidity testing using the nuclear method	ASTM D 3017/88** (NUCLEAR SYSTEM)	
Load plate test UNE 7391	DIN 18134:2012-04 (or NLT-357) ASTM D1194 could be used in case the above-mentioned standard is not available.	2 per hardstand on completed surface

Hardstand design

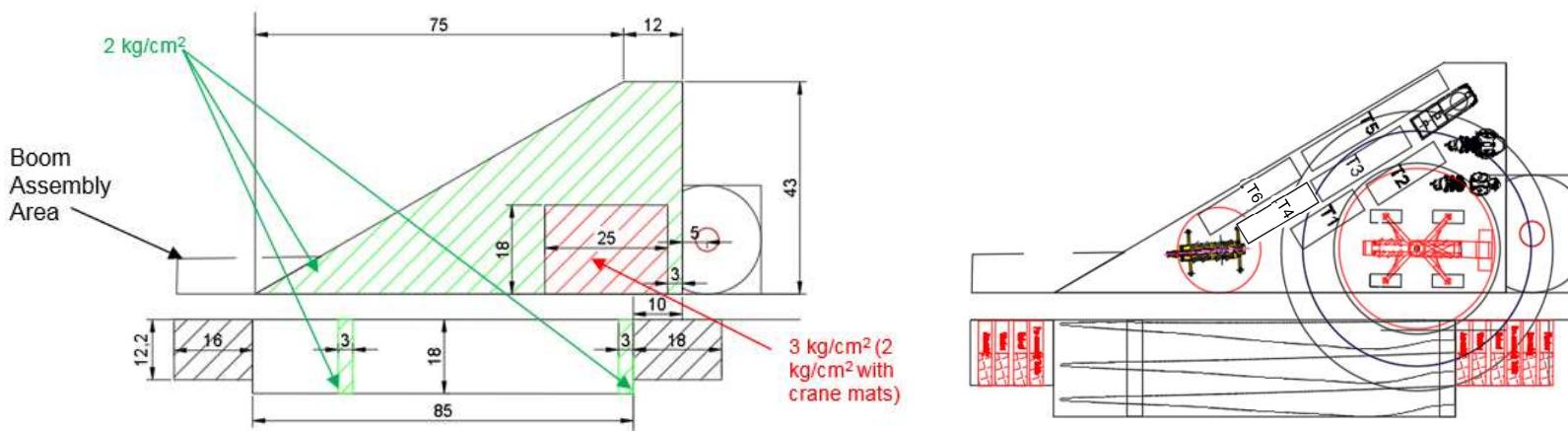
(Note) – Following hardstand layouts covering tower section off-loading with cranes only. The specification does not consider tower section transport with clamp system (self-off-loading). Use of clamp system doesn't require cranes for off-loading but additional space for maneuvering of trailers to release the tower sections is needed. This will have an impact in hardstand layout and must be evaluated and approved project specific.
Following hardstand layouts are examples only based on current maturity of wind turbine development program. Changes cannot be ruled out.

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 has to be evaluated and approved project specific.

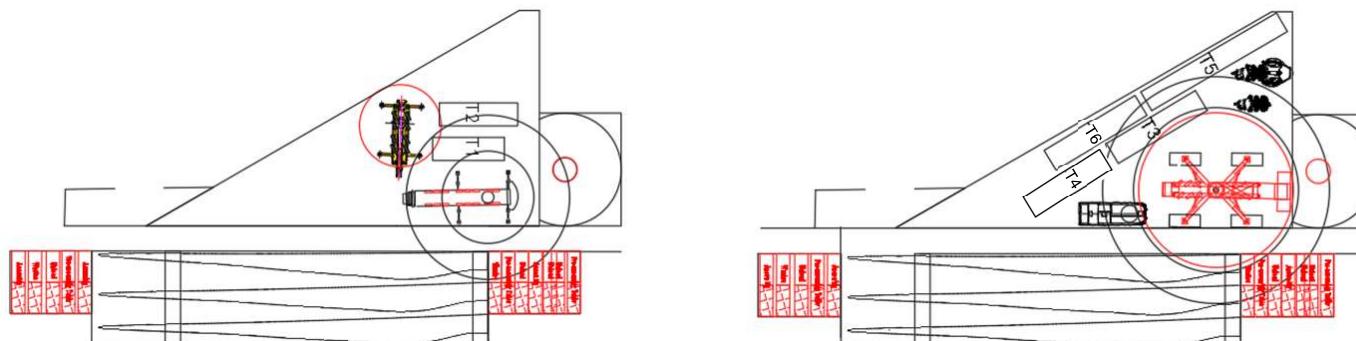
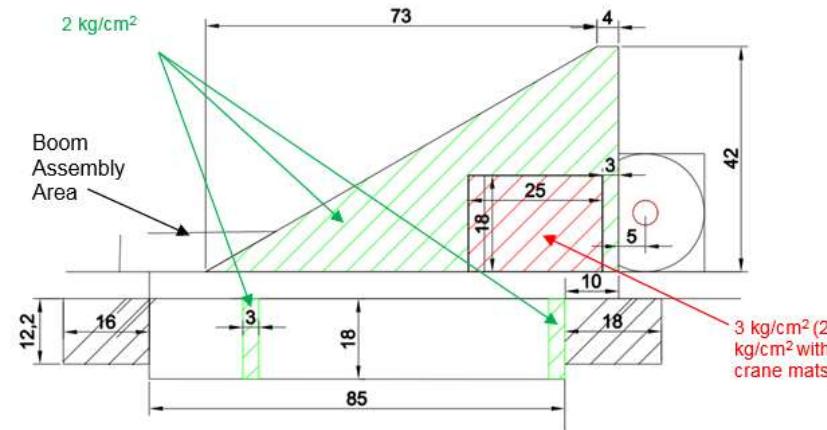
Hardstand design of T100m tubular steel tower configuration

Middle hardstand design

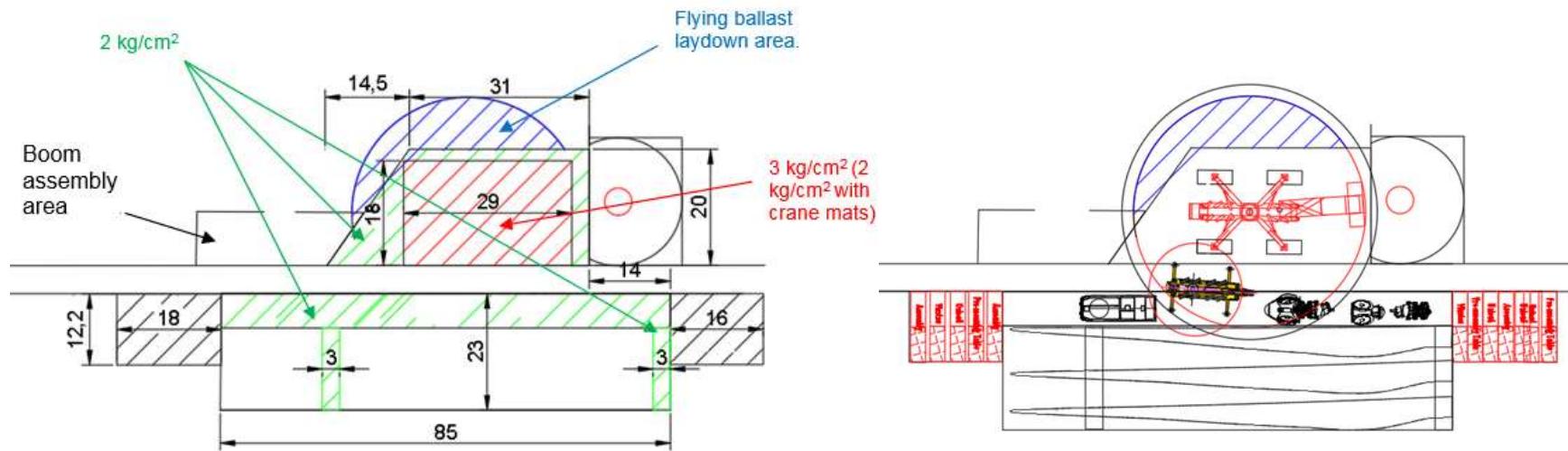
- Total storage – Assembly in 1 phase



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

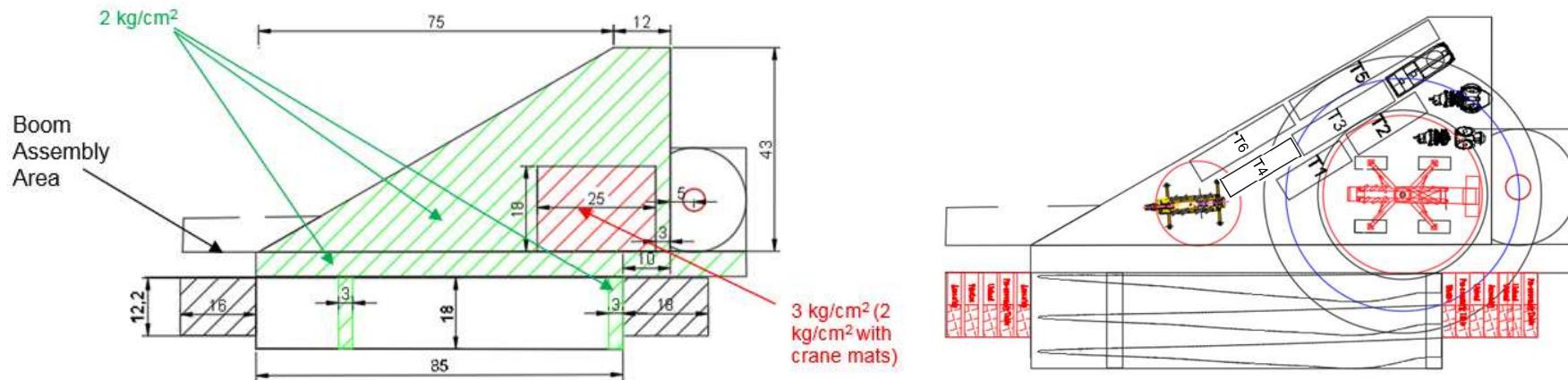


- Just in time assembly

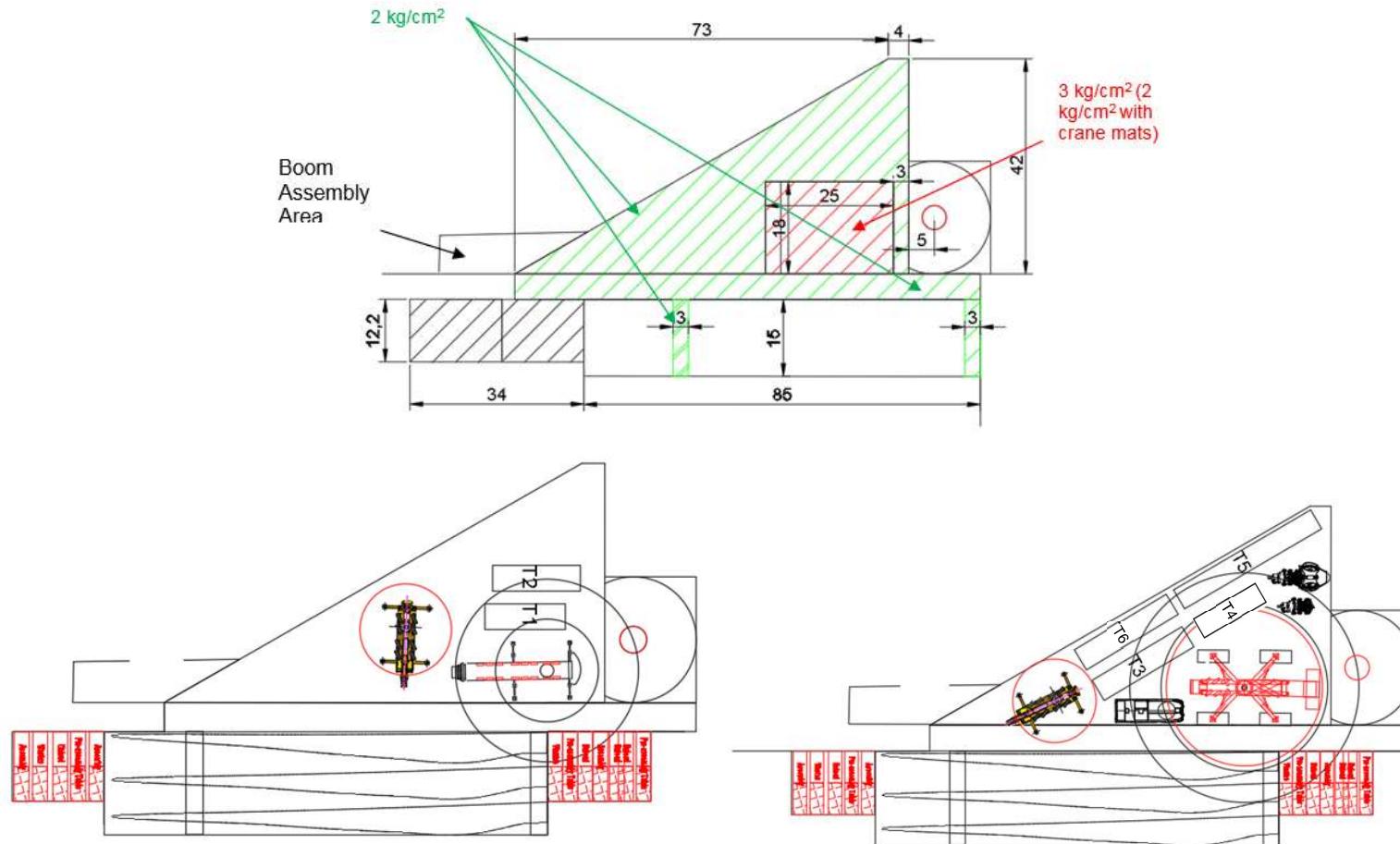


End-of-road hardstand design.

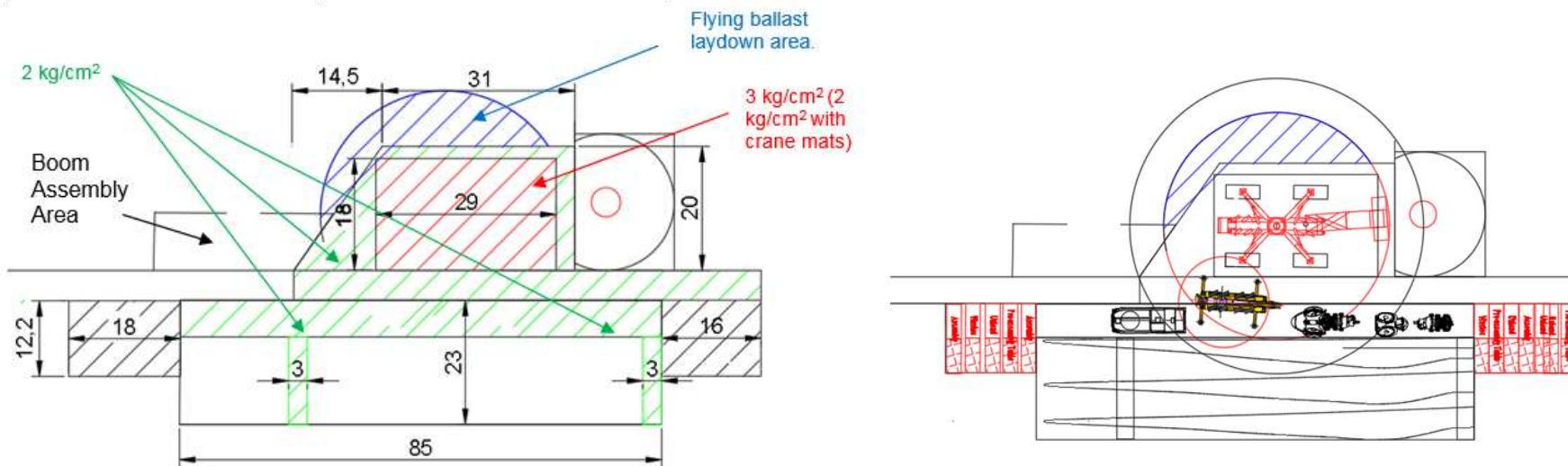
- Total storage – Assembly in 1 Phase



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



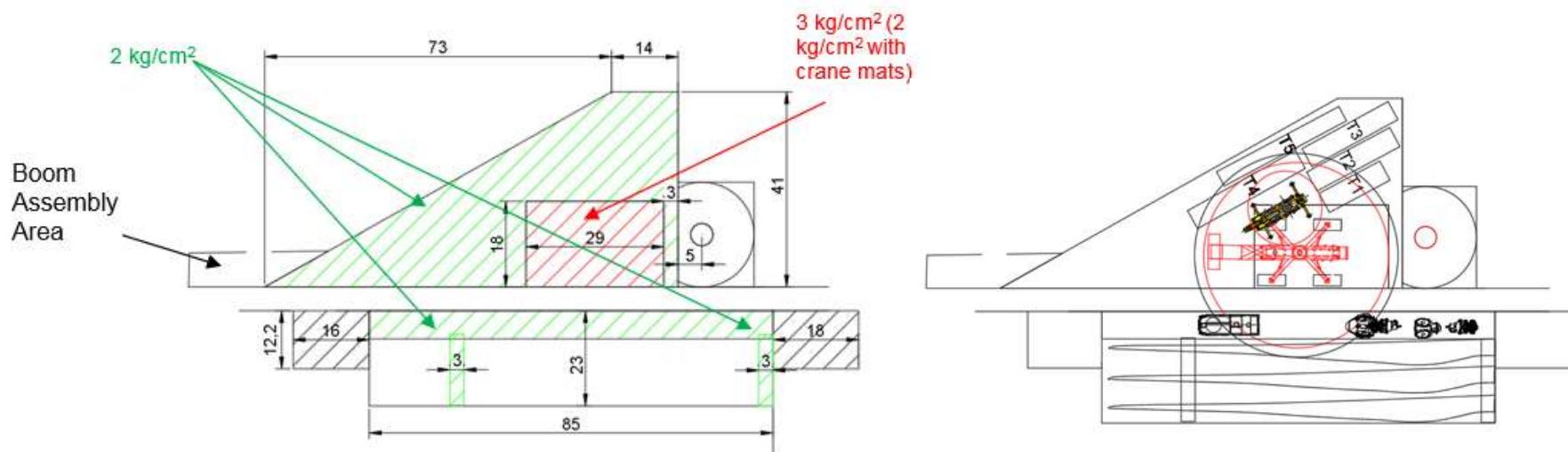
- Just in Time assembly



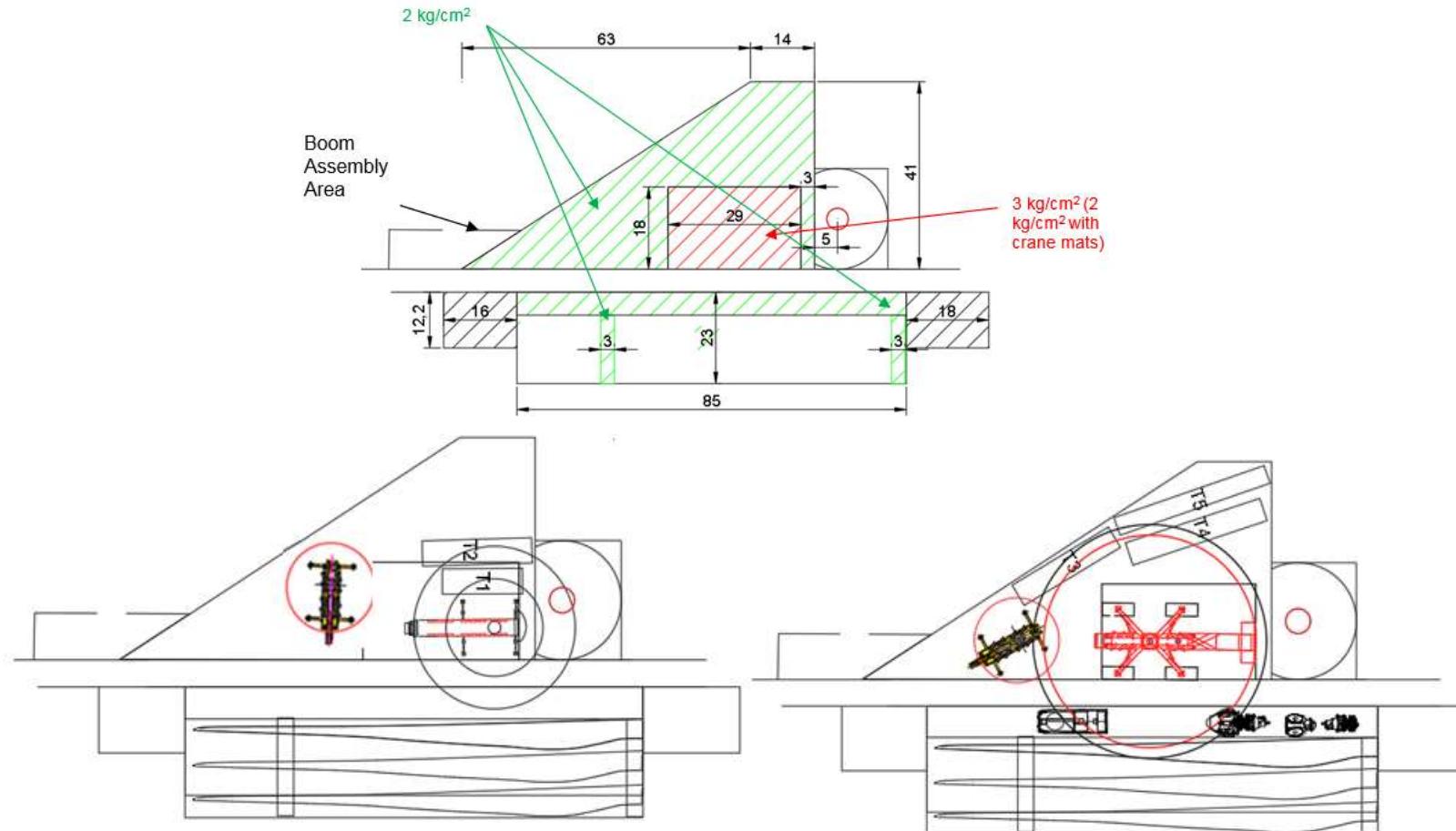
Hardstand design of T115m tubular steel tower configuration.

Middle hardstand design

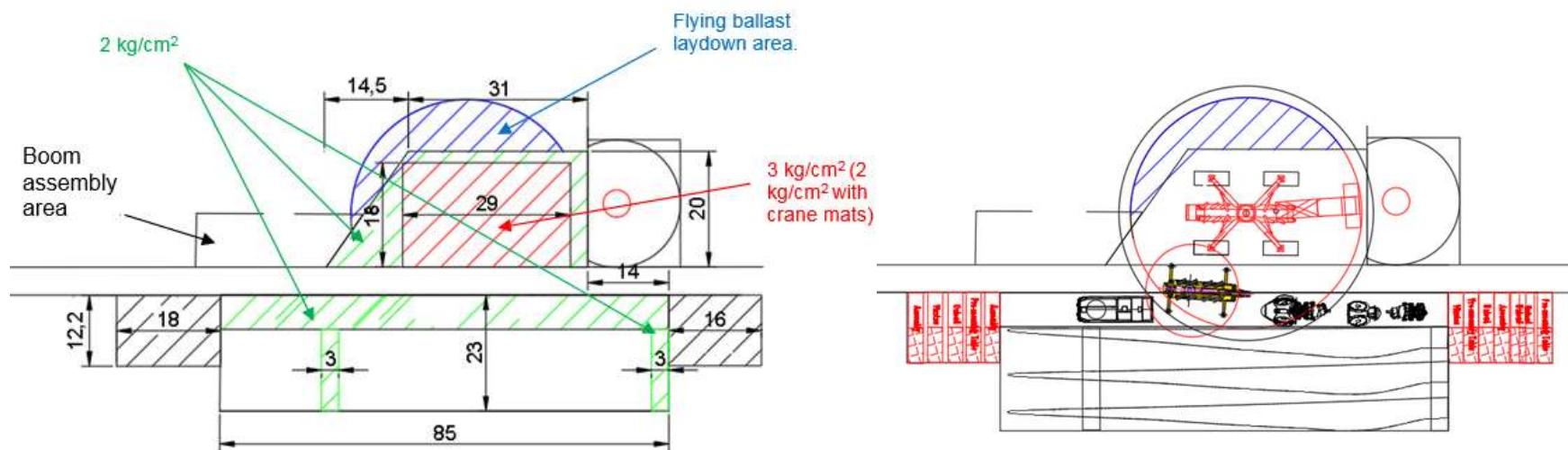
- Total storage – Assembly in 1 phase



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

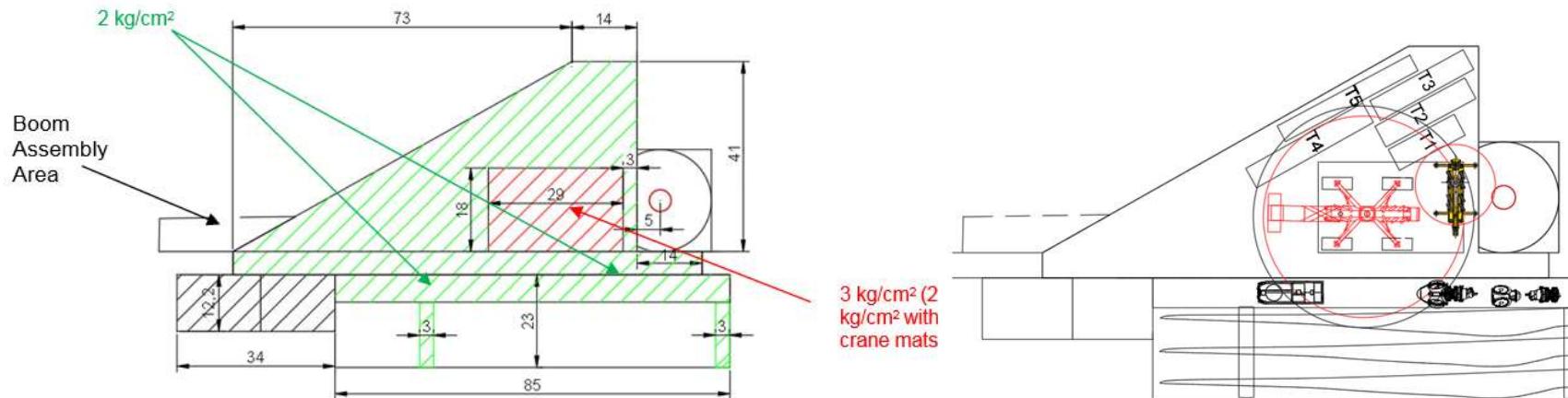


- Just in Time assembly

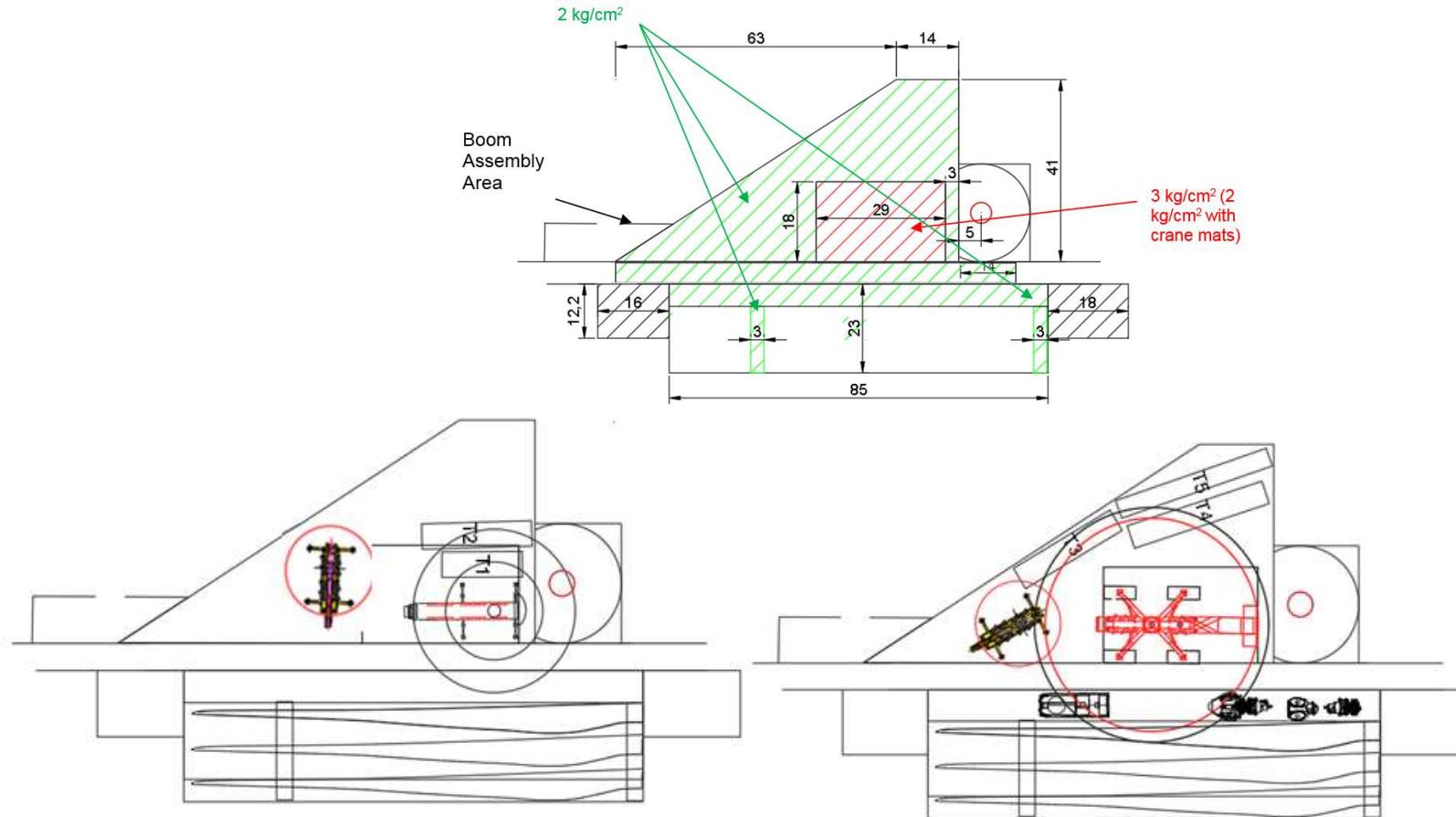


End-of-Road hardstand design

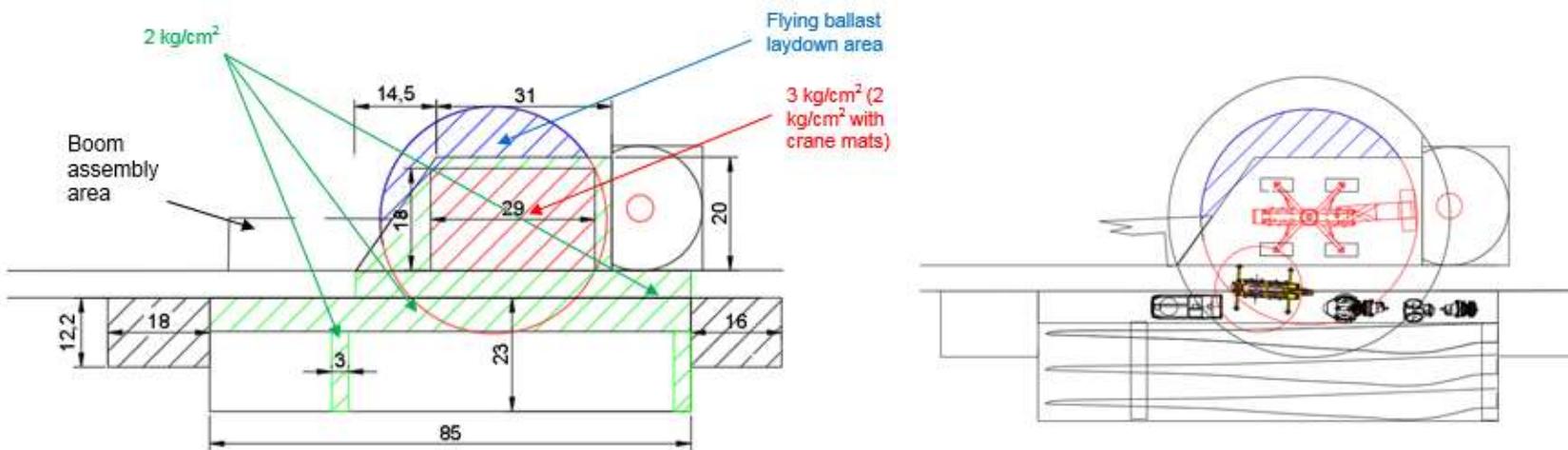
- Total storage – Assembly in 1 phase



- Partial Storage - Assembly in 2 phases (SGRE standard)



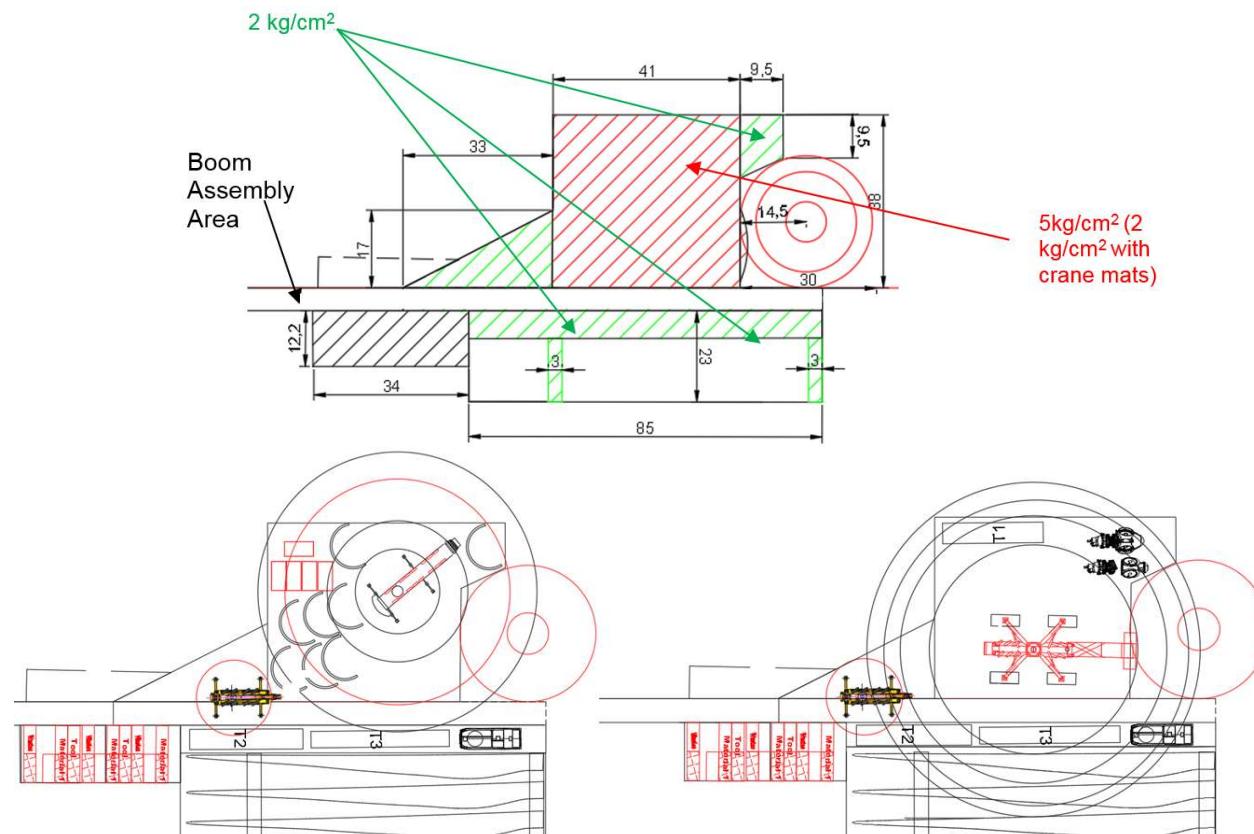
- Just in Time assembly



Hardstand design of T165m (MaxBögl) hybrid tower configurations

Middle- and end-of-road hardstand design

- Partial Storage - Assembly in 2 phases (SGRE standard)



Annexes

Weights and dimensions of components

The weights and dimensions to be considered for SG 6.0-170

100m tower (6 sections)

Element	W (kg)	L (m)	Ø Lower flange	Ø Upper Flange
Section 1	64422	10.270	4.500	4.500
Section 2	59948	13.105	4.500	4.500
Section 3	51990	15.210	4.500	4.490
Section 4	55474	19.105	4.490	4.480
Section 5	51191	21.300	4.480	4.020
Section 6	50410	18.700	4.020	3.570

115m tower

Element	W (kg)	L (m)	Ø Lower flange	Ø Upper Flange
Section 1	84941	13.540	4.700	4.670
Section 2	85087	18.190	4.670	4.440
Section 3	84979	23.740	4.440	4.430
Section 4	74187	27.000	4.430	3.560
Section 5	65517	29.945	3.560	3.357

165m MB tower (Preliminary version)

Element	W (kg)	L (m)	Ø Lower flange	Ø Upper Flange
Concrete (MB)	1598108	100.290	7.888	4.668
Section 1	69404	17.970	4.300	4.300
Section 2	50607	21.385	4.300	4.300
Section 3	58640	21.531	4.300	3.574

Nacelle, incl. TU and GEN

Element	W (kg)	L (m)	Width (m)	Height (m)
Nacelle	98000	14.614	4.72	3.405

Full Drive Train

Element	W (kg)	L (m)	Width (m)	Height (m)
Drive Train	76300	6.680	3.200	2.300

Hub

Element	W (kg)	L (m)	Width (m)	Height (m)
Hub	54900	4.184	4.636	4.005

Blades

Element	W (kg)	L (m)	Width (m)	Height (m)
Blade SG6.0-170	24600	73.500	4.500	3.400

Transformer Unit

Element	W (kg)	L (m)	Width (m)	Height (m)
TU	17700	-	-	-

Generator

Element	W (kg)	L (m)	Width (m)	Height (m)
GEN	16500	-	-	-

Note:

Approximate component weights and dimensions. **Not** considered transport tools, unloading toolkits and assembly toolkits

Turning radii and transport types

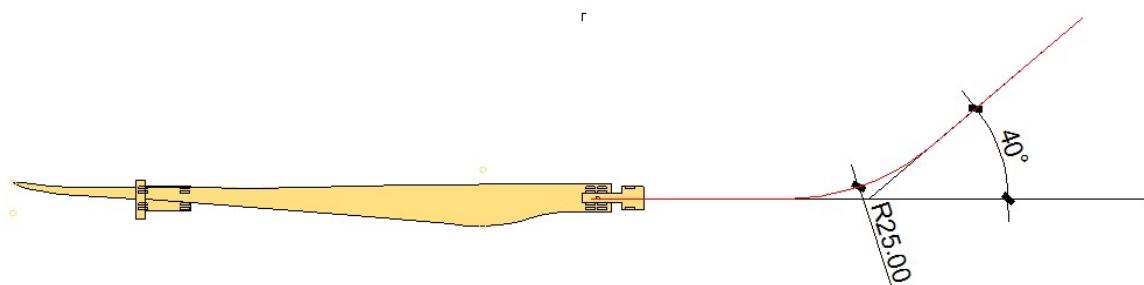
Aim

The purpose of this study is to analyze the trajectory of special vehicles used to transport the components of wind turbines.

A typical 4-metre-wide site road is considered in this requirement document.
Independent of specific radius it's as minimum required to extend the site road to 5m width at the beginning of a trajectory (Trajectory entrance).
All values listed in following items are based on 5m width of site road at trajectory entrance (defined as A1 = baseline of trajectory road width).

It will be determined the extra widening needed to the baseline of 5m due to the cargo's overhang (both exterior and interior) and the extra widening for the extension of the proposed road along the different curves defined in this study.

These curves will be composed of a certain angle between alignments and a connecting radius between them. The alignment angles are between 0° and 180° with 10° intervals, and radius between 5m and 90m with 5m intervals.



Scope

The means of transport defined will be the most representative for transporting the SG 6.0-170 wind turbine's large components.

Methodology

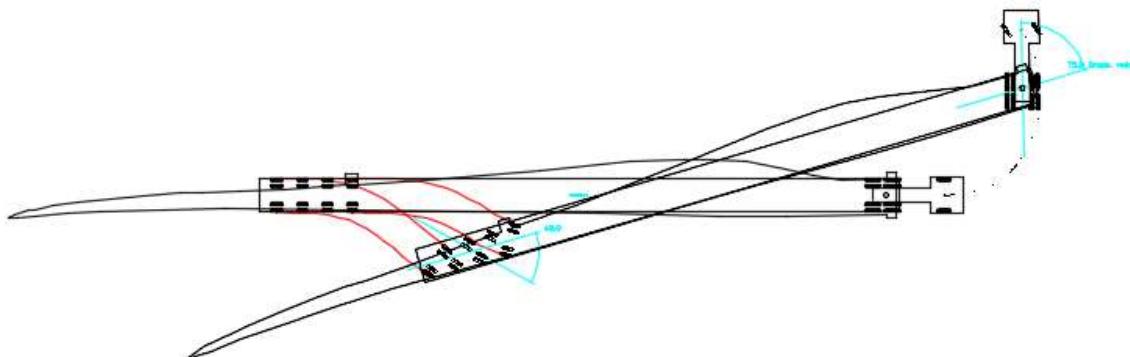
The following points have been detailed when writing the study:

- Starting conditions
- Defining the geometry of special vehicles for all components
- Determining the critical vehicle for modelling
- Defining trajectories
- Critical points of cargo
- Extra widening

Starting condition

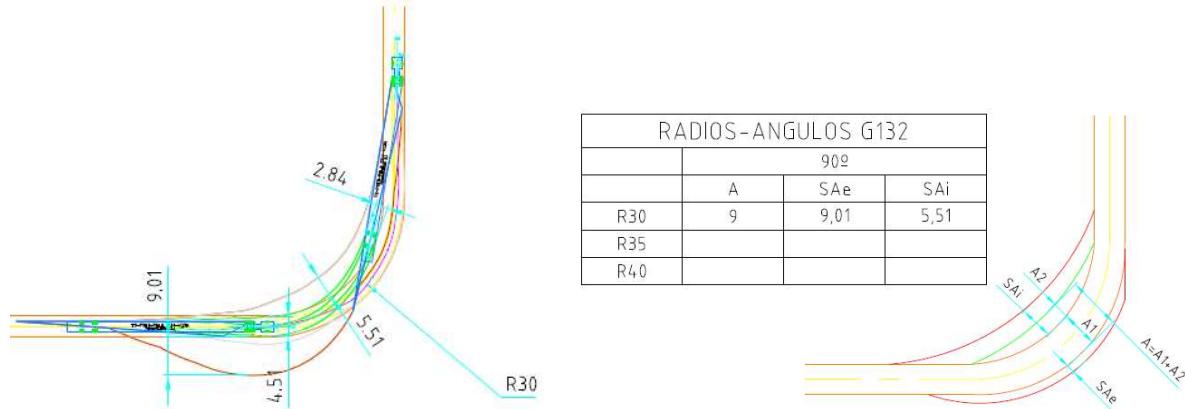
The determining factors imposed for modelling are the following:

- If the vehicle's track width is $\leq 4.5\text{m}$, in the table $A=5\text{m}$ ($> 4.5\text{m}$ in the example).
- If the vehicle's track is $> 4.5\text{m} \leq 5.5\text{m}$, $A=6\text{m}$.
- If the vehicle's track is $> 5.5\text{m} \leq 6.5\text{m}$, $A=7\text{m}$, and so on.
- If the trailer's track must go inside the curve, add the dimension "A" previously calculated to said dimension and round the sum to the next 0.5m. (in the example: $A= A_1+A_2= 6\text{m} + 2.84\text{m}= 8.84\text{m}$ and round to 9m).
- SA_i will always be measured from the interior line of the 5m baseline road width regardless of the "A" height and rounded to the next 0.5m (5.51m rounded to 6m in the example).
- SA_e will always be measured from the exterior line of the 5m baseline road width regardless of the "A" height and rounded to the next 0.5m. (9.01m round to 9.5m in the example).
- The tractor will always go on the outside of the curve and the trailer on the inside.
- In no case will the tractor and trailer tracks go outside the curve.
- If, with the bed turned to its maximum (40° in the example), the lorry exceeds a turning angle with respect to this of 75°, the route will be disregarded.



Example of limitations on the directional systems of a vehicle

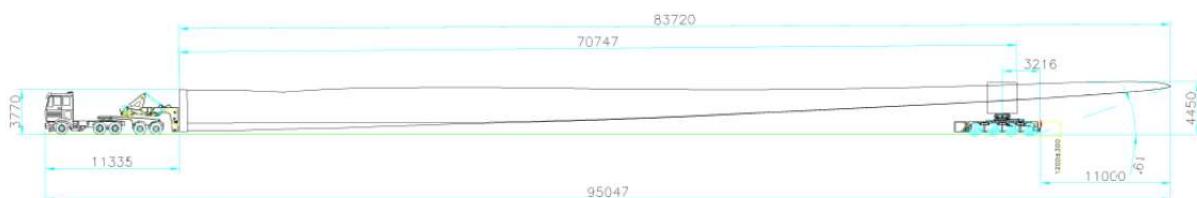
The data to be obtained by means of the graphical study on the modelling carried out will need to be set out in the following way.



Example of taking of data from the graphical representation

Defining the geometry of special vehicles

Drawing shall cover the most restrictive transports with their respective cargo. Of all the vehicles needed to transport the SG 6.0-170 wind turbine components, the vehicles transporting the blades were modelled as they are the most restrictive in terms of dimensions. The different vehicles obtained are shown below:

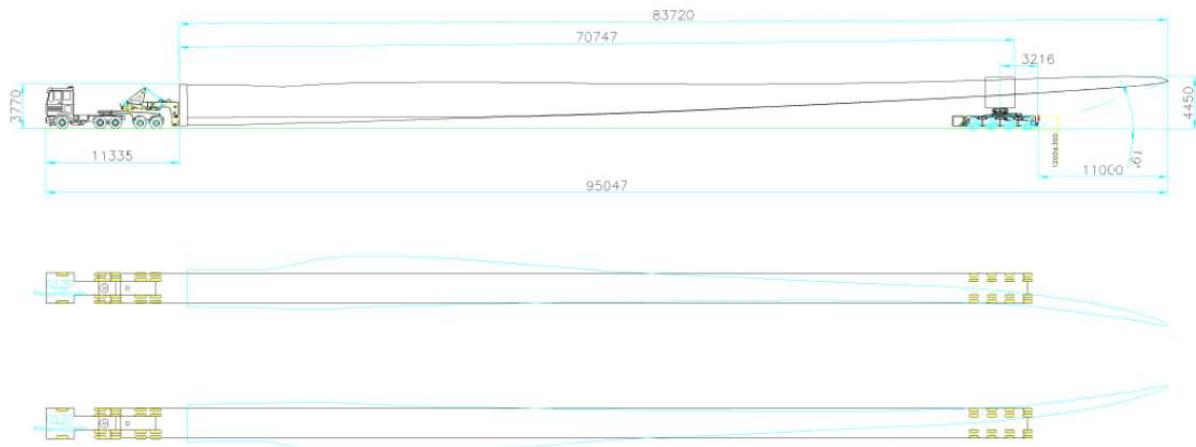


Determining the critical vehicle for modelling

From the above vehicles, the critical ones are those that possess some of the following characteristics:

- A high level of cargo overhang
- A long bed
- Elevated total length
- Low rear axle turning angle

The modelling of the following has been proposed:



Defining trajectories

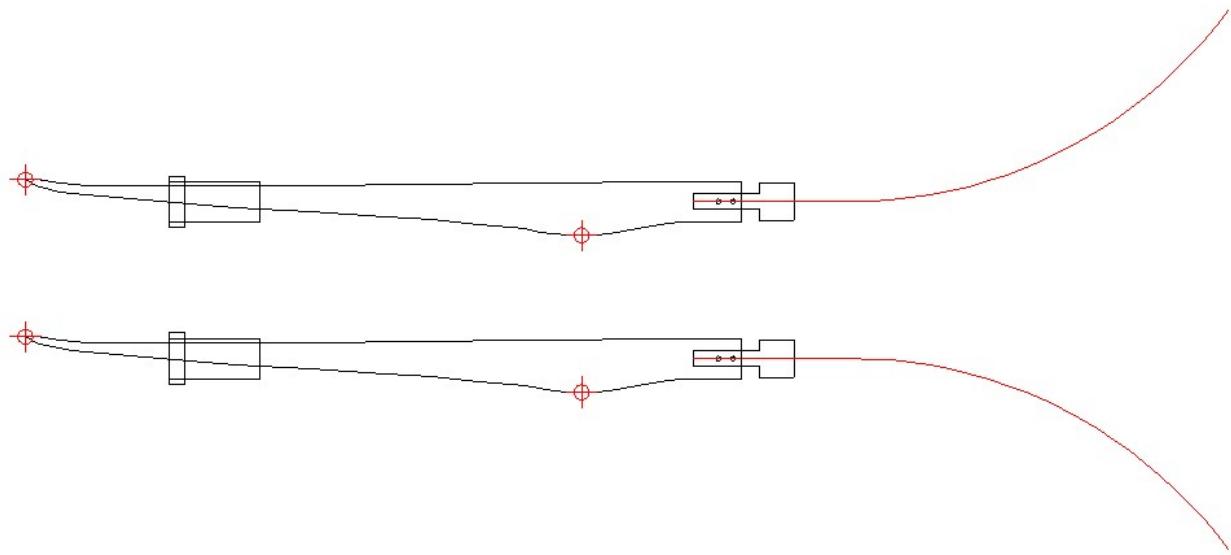
All the trajectories initially indicated in a table in which the abscissas represent the different angles of alignment and the ordinates the different radii of curvature have been digitally presented according to the following model:

Alineaciones (º)						
	0	10	20	30	...	180
Radios (m)	5					
10						
15						
20						
...						
100						

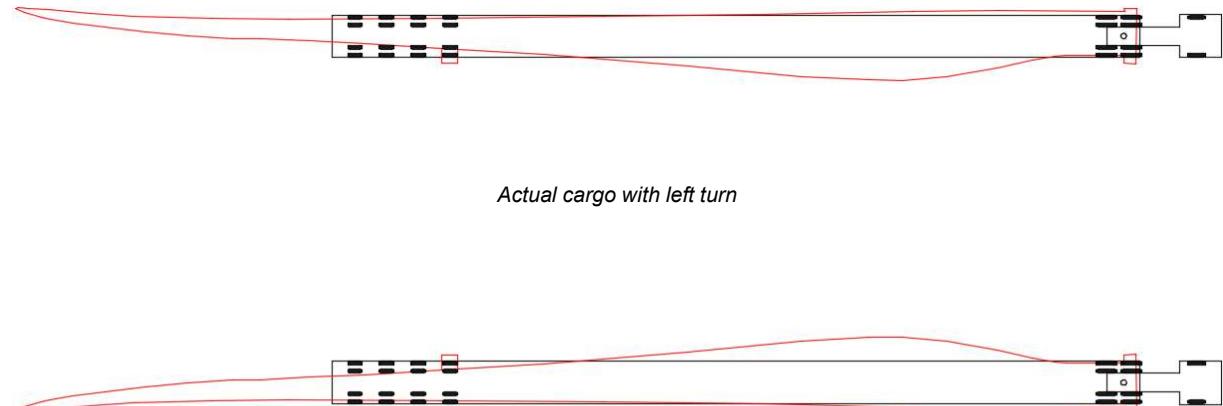
Critical points of CARGO

The proposed cargoes, wind turbine blades, are not symmetrical with respect to their central axis, so the occupation will vary according to whether the curve is a right or a left turn.

The critical points of both turns are shown below:



To cover right turns, the reflection as seen from below was used to make the most of the trajectory of the original template (with left turns), i.e. the same template was used but with the symmetry of the cargo with respect to the lorry axis.

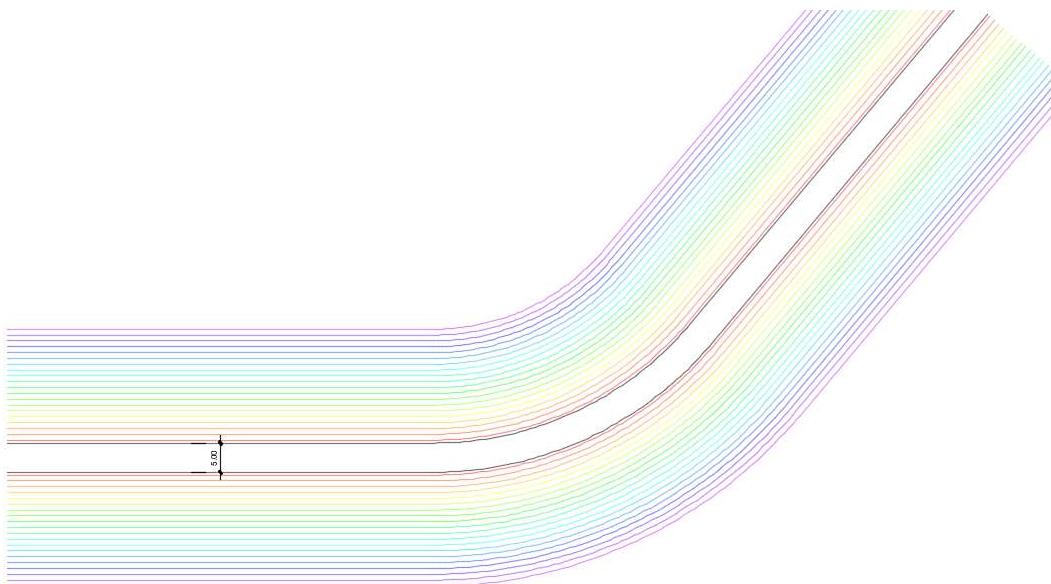


Symmetrical load with respect to the axis to simulate the right turn using the previous template

Extra Widening

To determine the widening needed, equal intervals of one metre were drawn to the starting road to determine the condition of each vehicle for each of the trajectories studied.

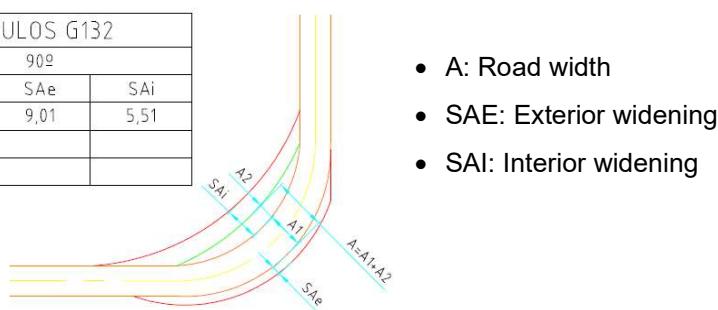
This initial road of 5 meters at point of trajectory entrance (baseline) and the necessary widening for the feasibility of transport on both sides will be determined from its ends.



The equal intervals to the sweep of the special vehicle models can be determined in this way, on the one hand through the vehicle envelope, indicating the sweep of the road, and on the other by characteristic lines or tracking points representing the sweep of the cargo's previously defined critical points.

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

RADIOS-ANGULOS G132			
	90°		
	A	SAe	SAi
R30	9	9,01	5,51
R35			
R40			

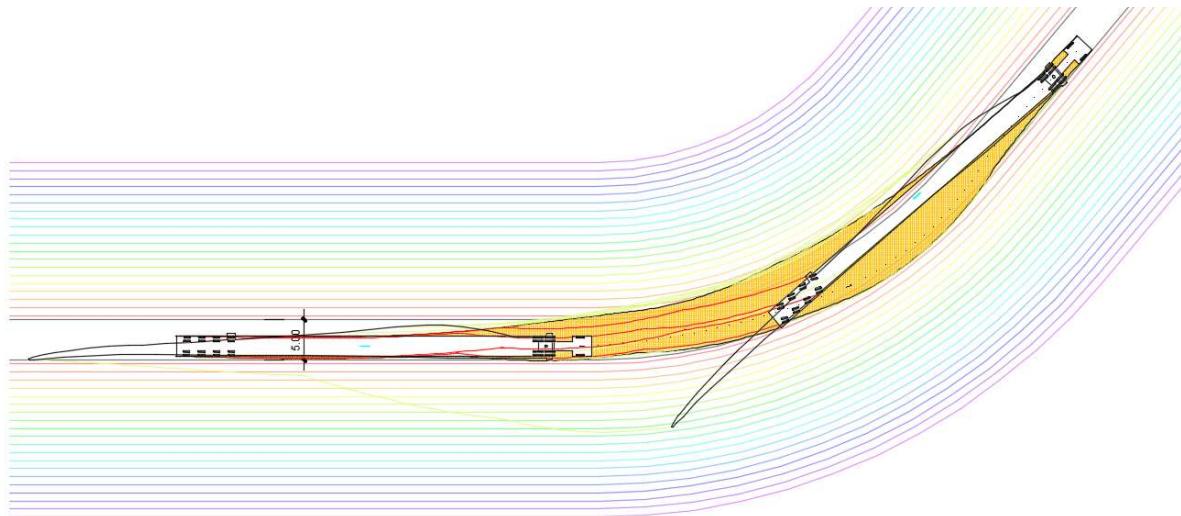


The conclusions of the study will be reflected in a table where:

- A: is the width of the road necessary for transport ($A = A_1 + A_2$)
- A1: represents the road width (at least 5 m at each point of trajectory = baseline), which may be increased depending on the width necessary for manoeuvring the vehicle
- A2: Is the occupation of the vehicle when manoeuvring cannot adjust to the A1 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
- R30: Represents the radius curve at the centre of the road

- 90°: Represents the angle formed by two straight sections of road joined by a curve of a given radius

The shading of the vehicle bed (in orange), the wheels of the axle groups (in red) and the lines of the critical points of the cargo (in yellow) are shown below.



The data represented below in the different tables of the study was obtained from the modelling, showing the following widening according to the cargo and bed.

requirements of trajectories

SG 6.0-170, left turn

Radios (m)	10°			20°			30°			40°			50°			60°		
	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	14	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	7	5	13,5	7	6	16,5
25	5	1,5	1	6	1,5	4,5	6	1,5	7,5	6	3	10	7	4,5	13	7	6	16
30	5	1,5	1	5	1,5	4,5	6	1,5	7	6	3	10	7	4,5	12,5	7	5,5	15
35	5	1,5	1	5	1,5	4	6	1,5	7	6	3	9,5	6	4	12	7	5,5	14,5
40	5	1,5	1	5	1,5	4	6	1,5	7	6	2,5	9	6	4	11,5	7	5	13,5
45	5	1,5	1	5	1,5	4	6	1,5	6,5	6	2,5	9	6	3,5	11	7	4,5	13
50	5	1,5	1	5	1,5	4	6	1,5	6,5	6	2,5	8,5	6	3,5	10,5	6	4,5	12
55	5	1,5	1	5	1,5	4	6	1,5	6	6	2,5	8	6	3,5	10	6	4	11,5
60	5	1,5	1	5	1,5	4	6	1,5	6	6	2	8	6	3	9,5	6	4	10,5
65	5	1,5	1	5	1,5	3,5	6	1,5	6	6	2	7,5	6	3	9	6	3,5	9,5
70	5	1,5	1	5	1,5	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	1	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

Radios (m)	70°			80°			90°			100°			110°			120°		
	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	8	37,5	6	0	0
25	7	7	19	8	8	22	9	8	25	12	8	29	15	8	33	6	0	0
30	7	6,5	17,5	8	7,5	20,5	8	8	23	10	8	26	13	8	29	16	8,5	33
35	7	6,5	16,5	7	7	19	8	8	21	8	8	23,5	10	8	26	12	8,5	28
40	7	6	15,5	7	7	17,5	7	7,5	19	8	8	20,5	8	8	22	8	8,5	23
45	7	5,5	14,5	7	6	16	7	7	17	7	7	18	7	7,5	18,5	7	7,5	18,5
50	7	5	13,5	7	5,5	14,5	7	6	15	7	6,5	15,5	7	6,5	15,5	7	6,5	15,5
55	7	4,5	12,5	7	5	13	7	5,5	13	7	5,5	13	7	5,5	13	7	5,5	13
60	6	4,5	11	6	4,5	11,5	6	5	11,5	6	5	11,5	6	5	11,5	6	5	11,5
65	6	4	10	6	4	10	6	4	10	6	4	10	6	4	10	6	4	10
70	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9
75	6	3	8,5	6	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

Radios (m)	130°			140°			150°			160°			170°			180°		
	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	6	0	0
15	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
20	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
25	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
30	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0	6	0	0
35	15	8,5	31	19	8,5	35	6	0	0	6	0	0	6	0	0	6	0	0
40	9	8,5	24	11	8,5	25,5	12	8,5	26	14	8,5	27,5	16	8,5	29	18	8,5	31
45	7	7,5	18,5	7	7,5	18,5	8	7,5	18,5	8	7,5	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	15,5	7	6,5	15,5	7	6,5	15,5	7	6,5	15,5
55	7	5,5	13	7	5,5	13	7	5,5	13	7	5,5	13	7	5,5	13	7	5,5	13
60	6	5	11,5	6	5	11,5	6	5	11,5	6	5	11,5	6	5	11,5	6	5	11,5
65	6	4	10	6	4	10	6	4	10	6	4	10	6	4	10	6	4	10
70	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9	6	3,5	9
75	6	3	8,5	6	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

SG 6.0-170, right turn

Radios (m)	10°			20°			30°			40°			50°			60°		
	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	9,5	14	7	10,5	17,5
20	5	4	2	6	5,5	5	6	7,5	8	6	8,5	11	7	9,5	14	7	10	16,5
25	5	4	2	6	5,5	5	6	7,5	8	6	8,5	10,5	7	9,5	13,5	7	10	16
30	5	4	2	5	5,5	5	6	7	7,5	6	8,5	10,5	7	9	13	7	10	15,5
35	5	4	2	5	5,5	5	6	7	7,5	6	8	10	6	9	12,5	7	9,5	14,5
40	5	4	2	5	5,5	5	6	7	7,5	6	8	9,5	6	9	12	7	9,5	14
45	5	4	2	5	5,5	5	6	7	7,5	6	8	9,5	6	8,5	11,5	7	9,5	13,5
50	5	4	2	5	5,5	4,5	6	7	7	6	8	9	6	8,5	11	6	9	12,5
55	5	4	2	5	5,5	4,5	6	7	7	6	8	9	6	8,5	10,5	6	9	11,5
60	5	4	2	5	5,5	4,5	6	6,5	6,5	6	7,5	8,5	6	8,5	10	6	9	11
65	5	4	2	5	5,5	4,5	6	6,5	6,5	6	7,5	8	6	8	9,5	6	8,5	10,5
70	5	4	2	5	5,5	4,5	6	6,5	6,5	6	7,5	8	6	8	9	6	8,5	9,5
75	5	4	2	5	5,5	4,5	6	6,5	6	6	7	7,5	6	7,5	8,5	6	8	9
80	5	4	2	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	6	7,5	7,5	
90	5	4	2	5	5,5	4	5	6,5	5,5	5	7	6,5	6	7	6	7	7	

Radios (m)	70°			80°			90°			100°			110°			120°		
	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	32	18	11	37,5			
25	7	10,5	19	8	11	22	9	11	25	12	11	29	15	11	33			
30	7	10,5	17,5	8	10,5	20,5	8	11	23	10	11	26	13	11	29	16	11	33
35	7	10	16,5	7	10,5	19	8	11	21	8	11	23,5	10	11	26	12	11	28
40	7	10	15,5	7	10,5	17,5	7	10,5	19	8	11	20,5	8	11	22	8	11	23
45	7	9,5	14,5	7	10	16	7	10,5	17	7	10,5	18	7	10,5	18,5	7	10,5	18,5
50	7	9,5	13,5	7	9,5	14,5	7	10	15,5	7	10	15,5	7	10	15,5	7	10	15,5
55	7	9,5	12,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5
60	6	9	11,5	6	9	12	6	9	12	6	9	12	6	9	12	6	9	12
65	6	8,5	10,5	6	8,5	10,5	6	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5
70	6	8,5	9,5	6	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)	130°			140°			150°			160°			170°			180°		
	A	Sae	Sai															
5																		
10																		
15																		
20																		
25																		
30																		
35	15	11	31	19	11	35												
40	9	11	24	11	11	25,5	12	11	26	14	11	27	16	11	29	18	11	31
45	7	10,5	18,5	7	10,5	18,5	8	10,5	18,5	8	10,5	18,5	8	10,5	18,5	8	10,5	18,5
50	7	10	15,5	7	10	15,5	7	10	15,5	7	10	15,5	7	10	15,5	7	10	15,5
55	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5	7	9,5	13,5
60	6	9	12	6	9	12	6	9	12	6	9	12	6	9	12	6	9,5	12
65	6	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5	6	9	10,5
70	6	8,5	9,5	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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ANNEX 2.- CÀLCULS JUSTIFICATIUS

ÍNDEX ANNEX 2

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1.- POTÈNCIA NOMINAL EN BT EN CT 30/0,69 KV

$$P_{ap} = \frac{P_g}{\cos \varphi}$$

$$P_{ap} = \frac{6.200}{0,90}$$

$$P_{ap} = 6.889 \text{ kVA}$$

S'instal·la un transformador de 7.200 kVA.

2.- INTENSITATS NOMINALS EN MT EN CT 30/0,69 KV

$$I = \frac{P_{ap}}{\sqrt{3} \cdot \cos \varphi \cdot V}$$

$$I = \frac{6.200}{\sqrt{3} \cdot 0,90 \cdot 30}$$

$$I = 132,58 \text{ A}$$

3.- CÀLCUL LÍMIT TÈRMIC DE LA XARXA MT

Els cables per a la xarxa de mitja tensió seran unipolars, aïllament polietilè reticulat d'alumini 18/30 kV HEPRZ1 i les seccions utilitzades seran: 95, 240, 400 i 630 mm² en alumini.

Les intensitats màximes admeses per aquest tipus de cables són les següents:

Secció (mm ²)	Intensitat admissible (A)
95 Al	215
240 Al	365
400 Al	470
630 Al	615

Les seccions del cable s'adaptaran a cada tram per no superar en cap cas el límit tèrmic del conductor.

4.- CÀLCUL DE CAIGUDES DE TENSIÓ DE LA XARXA MT

El càlcul i el dimensionament del cable previst per a la xarxa interior de distribució subterrània de mitja tensió per a l'evacuació de la potència generada a cada aerogenerador, s'adjunta a la llista següent, on es poden observar les caigudes de tensió parcials a cadascun dels trams entre aerogeneradors i totals a cadascun dels trams.

La fórmula utilitzada és:

$$\Delta V = \sqrt{3} \cdot L \cdot (R \cdot \cos \varphi + X \cdot \sin \varphi)$$

en la qual:

ΔV = Caiguda de tensió en V

I = Intensitat prevista al tram corresponent en A

L = Longitud del tram de càlcul, en Km.

R = Resistència elèctrica a 105°C i 50 Hz. ($\Omega/\text{Km.}$)

X = Reactància a $f=50$ Hz. ($\Omega/\text{Km.}$)

Cos φ = Factor de potència de la instal·lació (0,95)

Per als conductors utilitzats i segons dades del fabricant:

Secció (mm ²)	R ($\Omega/\text{km.}$)	X ($\Omega/\text{km.}$)
95 Al	0,430	0,129
240 Al	0,168	0,109
400 Al	0,105	0,102
630 Al	0,060	0,093

A continuació, s'adjunten càlculs justificatius de la secció triada a cadascun dels trams dels circuits de la xarxa subterrània de mitja tensió en projecte. En aquesta llista s'han definit dos nous paràmetres:

- “K” és una constant utilitzada per al càlcul de caigudes de tensió:

$$K = \frac{U(\text{kV}) \cdot 10}{\sqrt{3} \cdot (R \cdot \cos \varphi + X \cdot \sin \varphi)} \text{ per al cas de línies subterrànies}$$

- “G.U.(%)” és el grau d'utilització del conductor:

$$G.U. = \frac{I}{I_{\max,f}} \cdot 100$$

	Sección	R (105°C) (Ohm/km)	X (Ohm/km)	cos fi	U (kV)	I _{max} (A)	I _{max} (A) Catálogo	coef.**
Conductor:	95	0,430	0,129	0,90	30	215	215	1,00
	240	0,168	0,109	0,90	30	365	365	1,00
	400	0,105	0,102	0,90	30	470	470	1,00
	630	0,060	0,093	0,90	30	615	615	1,00

PE TOSSAL DEL LLANGOST

8 x SG170-6.200 KW

	DE	A	L(KM)	P(Kw)	I(A)	nº cir.	coef.* (directament e enterrado)	ladm(A)	S	e%	e%total	p(kw)	p%	G.U.(%)	
CIRCUITO 1	4	SET	7,317	18.600	397,73	3	0,73	448,95	630	1,59%	2,44%	208,91	0,42%	88,59%	
	5	4	1,154	12.400	265,15	2	0,83	302,95	240	0,35%	0,85%	40,89	0,08%	87,52%	
	6	5	1,456	6.200	132,58	2	0,83	178,45	95	0,49%	0,49%	33,02	0,07%	74,29%	
													Pérdida pot. (kW)	282,82	0,57%

	DE	A	L(KM)	P(Kw)	I(A)	nº cir.	coef.* (directament e enterrado)	ladm(A)	S	e%	e%total	p(kw)	p%	G.U.(%)	
CIRCUITO 2	1	SET	4,871	18.600	397,73	3	0,73	448,95	630	1,06%	1,93%	139,07	0,28%	88,59%	
	2	1	0,652	12.400	265,15	2	0,83	302,95	240	0,20%	0,87%	23,11	0,05%	87,52%	
	3	2	1,976	6.200	132,58	2	0,83	178,45	95	0,67%	0,67%	44,81	0,09%	74,29%	
													Pérdida pot. (kW)	206,98	0,42%

	DE	A	L(KM)	P(Kw)	I(A)	nº cir.	coef.* (directament e enterrado)	ladm(A)	S	e%	e%total	p(kw)	p%	G.U.(%)	
CIRCUITO 3	9	SET	5,790	12.400	265,15	3	0,73	343,10	400	1,23%	1,53%	128,22	0,26%	77,28%	
	8	9	0,877	6.200	132,58	2	0,83	178,45	95	0,30%	0,30%	19,88	0,04%	74,29%	
													Pérdida pot. (kW)	148,10	0,30%

	95	240	400	630
Longitud total ternas conductor (km)	4,310	1,810	5,790	12,190

Total (km)	24,100
-------------------	---------------

Pérdida total (kW)	637,90
Pérdida total (%)	1,29%

Ternas de cable HEPRZ1 18/30 kV

Intensidades máx de catálogo para una terna de cables enterrada a 1 m de profundidad, temperatura de terreno 25 °C y resistividad térmica 1,5 K·m/W

Valores de Resistencia a 105°C y 50 Hz

Valores de Reactancia a 50 Hz

coef.* = coeficiente de corrección en función del número de ternas alojadas en la zanja

coef.**= coeficiente de corrección por profundidad de enterramiento a 1m y temperatura del suelo 25°C

DOCUMENT 2.- PRESSUPOST

ÍNDEX PRESSUPOST

1.- PRESSUPOSTOS PARCIALS	3
1.1.- OBRA CIVIL	3
1.2.- AEROGENERADORS	5
1.3.- INSTAL·LACIONS ELÈCTRIQUES.....	6
1.4.- SEGURETAT I SALUT LABORAL.....	7
2.- PRESSUPOST GENERAL	8

1.- PRESSUPOSTOS PARCIALS

1.1.- OBRA CIVIL

1.1.1. FONAMENTS AEROGENERADORS

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.1.1.1	Ud. Execució de fonaments d'aerogeneradors. Inclou excavació, subministrament, recollida i muntatge d'armadura, anivellació virola, formigonat i reblert amb material seleccionat.	8,000	100.000,00	800.000,00
1.1.1.2	Ud Canalitzacions elèctriques tubs PVC D=200 mm (cables 30 KV) & D=90 mm (F.O.). Inclòs segellat de tubs amb poliuretano. Segons plàtol	8,000	375,00	3.000,00

Total Fonaments Aerogeneradors (Euros) 803.000,00

1.1.2. PLATAFORMES DE MUNTATGE

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.1.2.1	Ud. Execució de plataformes de muntatge de dimensions 40 x 40, incloent moviment de terres i formació de ferms.	8,000	40.000,00	320.000,00

Total Plataformes de Muntatge (Euros) 320.000,00

1.1.3. RASES

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.1.3.1	m3 Aclarir i desbrossar el terreny. Executar segons PG-3. Amplada 4 m y 20 cm profunditat, excepte quan és paral·lela al vial, que seria d'amplària 2m.	11.400,000	0,47	5.358,00
1.1.3.2	ml Rases per cablejat, incloent excavació, farcits, arquetes, senyalització i canonades de PVC i formigó en els encreuaments.	14.250,000	15,00	213.750,00

Total Rases (Euros) 219.108,00

1.1.4 VIALS DEL PARC

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.1.4.1	ml Execució de nous vials i adequació de camins existents. Inclou moviment de terres, formació de ferms i instal·lació i muntatge d'obres de drenatge.	9.850,000	108,00	1.063.800,00

Total Vials del Parc (Euros) 1.063.800,00

1.1.5. VARIS

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.1.5.1	P.A. de superfície d'hidrosembrada talussos	1,000	10.000,00	10.000,00

Total Varis (Euros) 10.000,00

1.1.8 MESURES AMBIENTALS CORRECTORES

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.1.8.1	Ud Seguiment ambiental en obra	1,000	36.000,00	36.000,00
1.1.8.2	Ud Seguiment arqueològic	1,000	3.000,00	3.000,00
1.1.8.3	Ud Pla de prevenció d'incendis	1,000	3.000,00	3.000,00

Total Mesures Ambientals Correctores (Euros) 42.000,00

TOTAL OBRA CIVIL 2.457.908,00

1.2.- AEROGENERADORS

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.2.1	Aerogenerador 6200 kW amb torre de 115 m. Inclou: <ul style="list-style-type: none"> - Rotor (boixa i pales) - Gòndola (adaptador, corona de gir, xassís, generador, acoblament elàstic, fre, multiplicador, eix principal, rodament principal, sistema hidràulic, sistema d'orientació i altres sistemes auxiliars i carcassa) - Torre - Rodet d'ancoratge - Armari de potència i control - Bateria de compensació de reactiva - Protecció contra llamps - Transformador de potència (7200 kVA, 30/0,69 kV) a l'interior - Cel·les de connexió de 30 kV, a la base de l'aerogenerador - Sistema de telecontrol Es contempla el subministrament, el transport, el muntatge, les proves i la posada en marxa.	8	3.950.000,00	31.600.000,00

TOTAL AEROGENERADORS (Euros) 31.600.000,00

1.3.- INSTAL·LACIONS ELÈCTRIQUES

1.3.1 XARXA DE MITJA TENSIÓ

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.3.1.1	m Subministrament i estesa de cable HEPRZ1 3x1x95 Al 18/30 KV	4.310	12,63	54.435,30
1.3.1.2	m Subministrament i estesa de cable HEPRZ1 3x1x240 Al 18/30 KV	1.810	36,90	66.789,00
1.3.1.3	m Subministrament i estesa de cable HEPRZ1 3x1x400 Al 18/30 KV	5.790	41,08	237.853,20
1.3.1.4	m Subministrament i estesa de cable HEPRZ1 3x1x630 Al 18/30 KV	12.190	47,10	574.149,00
1.3.1.5	Ud Terminals unipolars (material + muntatge) connexió cel·les de línia aerogeneradors	39	142,51	5.557,89
1.3.1.6	Ud. Empalmaments unipolars (material + muntatge) (cada 1000 m de tirada contínua)	57	221,48	12.624,36
Total Xarxa de Mitja Tensió (Euros)				951.408,75

1.3.2 XARXA GENERAL DE POSADA A TERRA

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.3.2.1	m Subministrament i estesa de cable de Cu 50 mm ²	15.031,00	2,82	42.387,42
1.3.2.2	Ud Posada a terra de l'aerogenerador i centre de transformació de 4.500 kVA segons plànols del fabricants del aerogenerador i torre meteorològica.	8,00	1.056,00	8.448,00

Total Xarxa General de Posada a Terra (Euros) 50.835,42

1.3.3. XARXA DE TELECONTROL

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.3.3.1	Subministrament i estesa de cable de F.O. Monomodo, amb protecció mecànica antirosegadors i antihumitat per enterrar sense tub.	24.100,00	2,20	53.020,00

Total Xarxa Telecontrol (Euros) 53.020,00

TOTAL INSTAL·LACIONS ELÈCTRIQUES (Euros) 1.055.264,17

1.4.- SEGURETAT I SALUT LABORAL

Núm.	Designació	Unitats	P.U.	Total (Euros)
1.4.1	Pressupost de Seguretat i Salut Laboral.	1	40.610,69	40.610,69

TOTAL SEGURETAT I SALUT LABORAL **40.610,69**

2.- PRESSUPOST GENERAL

1.- OBRA CIVIL	2.457.908,00 euros
2.- AEROGENERADORS	31.600.000,00 euros
3.- INSTAL·LACIONS ELÈCTRIQUES	1.055.264,17 euros
4.- SEGURETAT I SALUT LABORAL	40.610,69 euros
TOTAL:	35.153.782,86 euros

El pressupost d'execució material del Parc eòlic TOSSAL DEL LLANGOST ascendeix a la quantitat de TRENTA-CINC MILIONS CENT CINQUANTA-TRES MIL SET-CENTS VUITANTA-DOS euros amb VUITANTA-SIS cèntims (35.153.782,86 €).

L'Enginyer Industrial al servei de SATEL

David Gavín Asso

Col·legiat N°15.212 del C.O.E.I.C.

DOCUMENT 3.- PLÀNOLS

ÍNDEX PLÀNOLS

- 1. Situació**
- 2. Emplaçament**
- 3. Planta General d'Instal·lacions**
- 4. Planta traçat de vials**
- 5. Secció tipus de vials**
- 6. Rases tipus**
- 7. Esquema unifilar M.T. del Parc.**
- 8. Xarxa de terres del Parc.**



SIEMENS Gamesa
RENEWABLE ENERGY

satel

AVANTPROJECTE:

PARC ÈOLIC "Tossal del Llangost"
EN ELS T.T.M.M. DE MONTOLIU DE SEGARRA, RIBERA D'ONDARA I TALAVERA (PROVINCIA DE LLEIDA)

DATA: FEBRER-2020

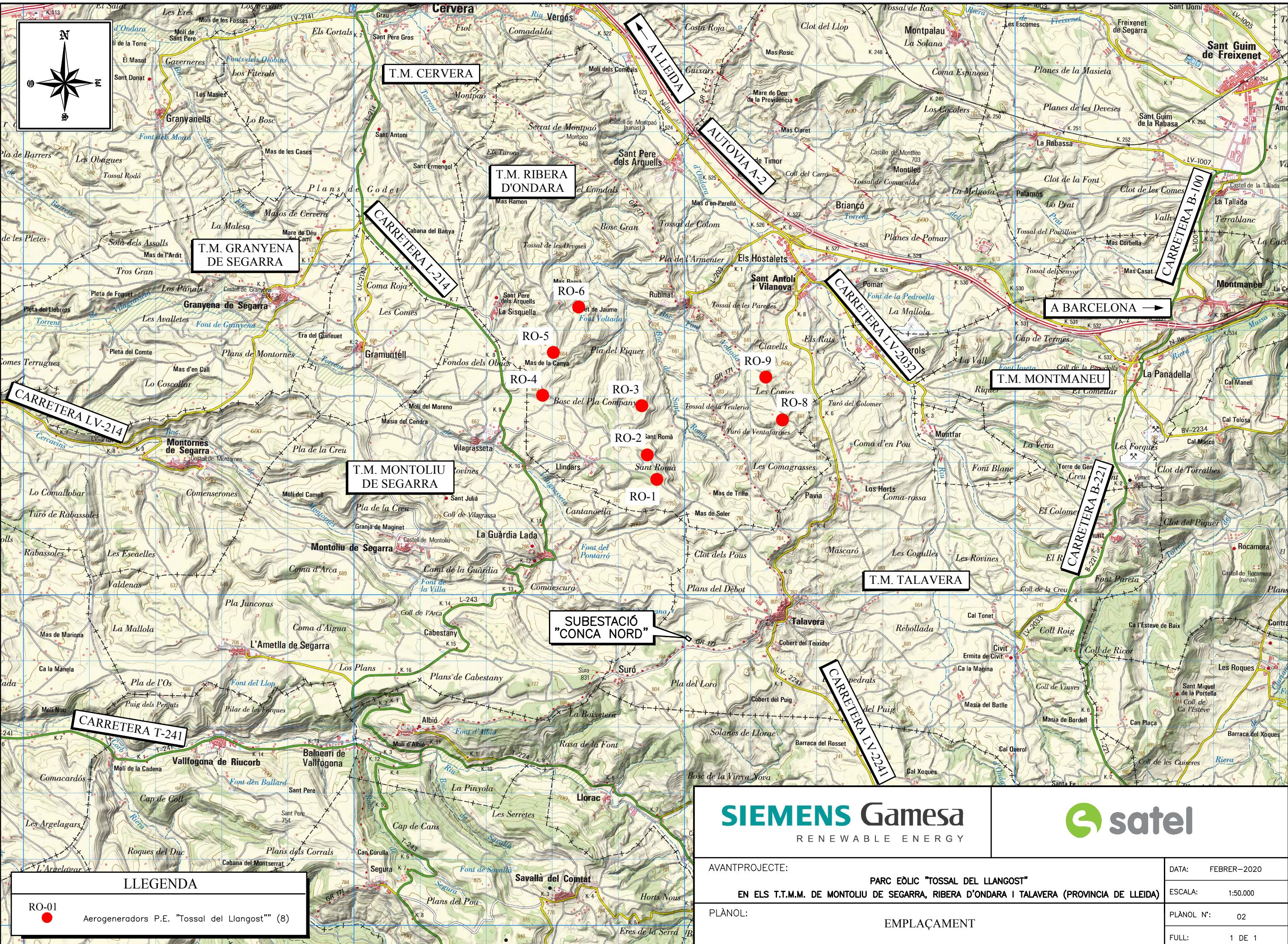
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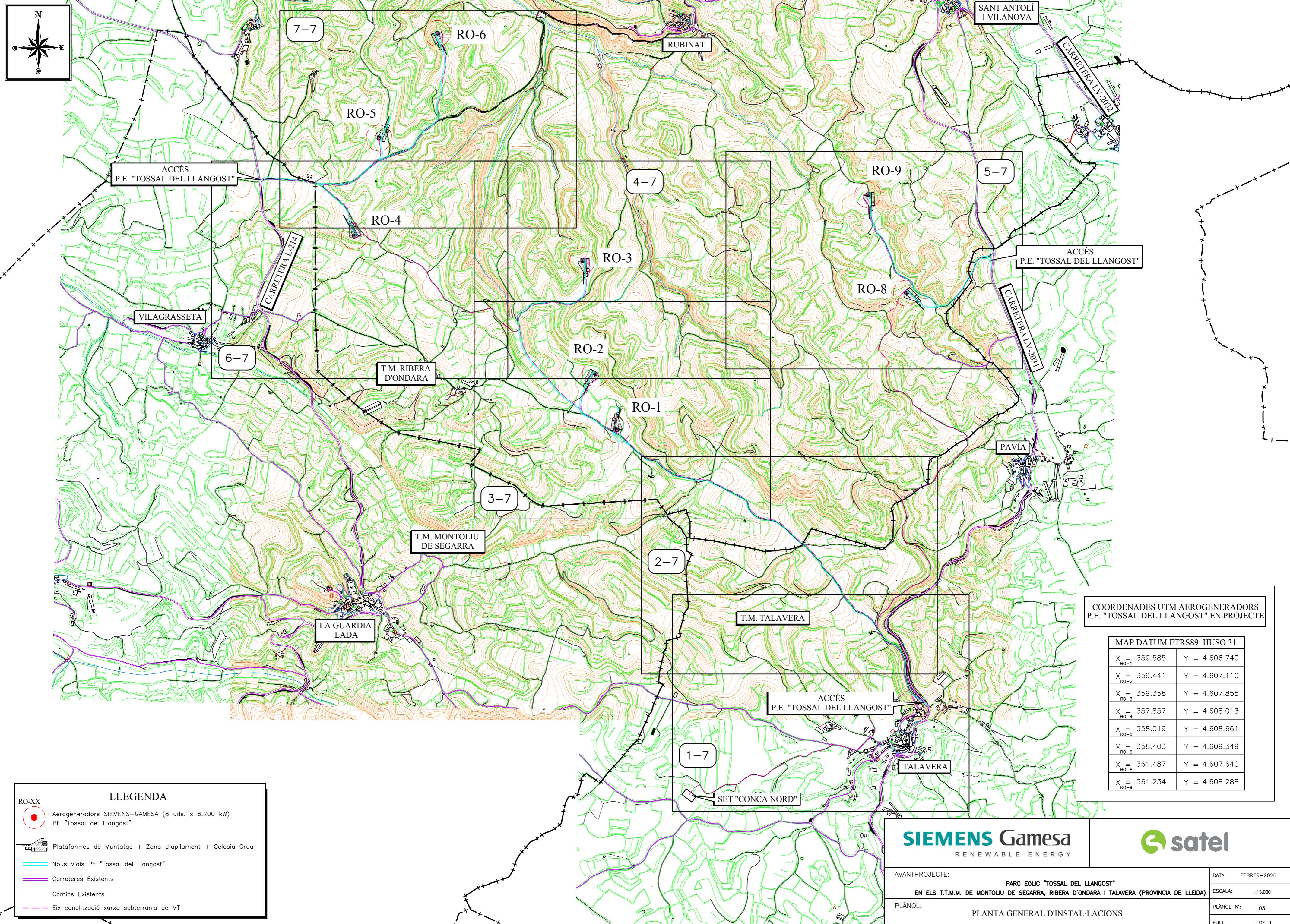
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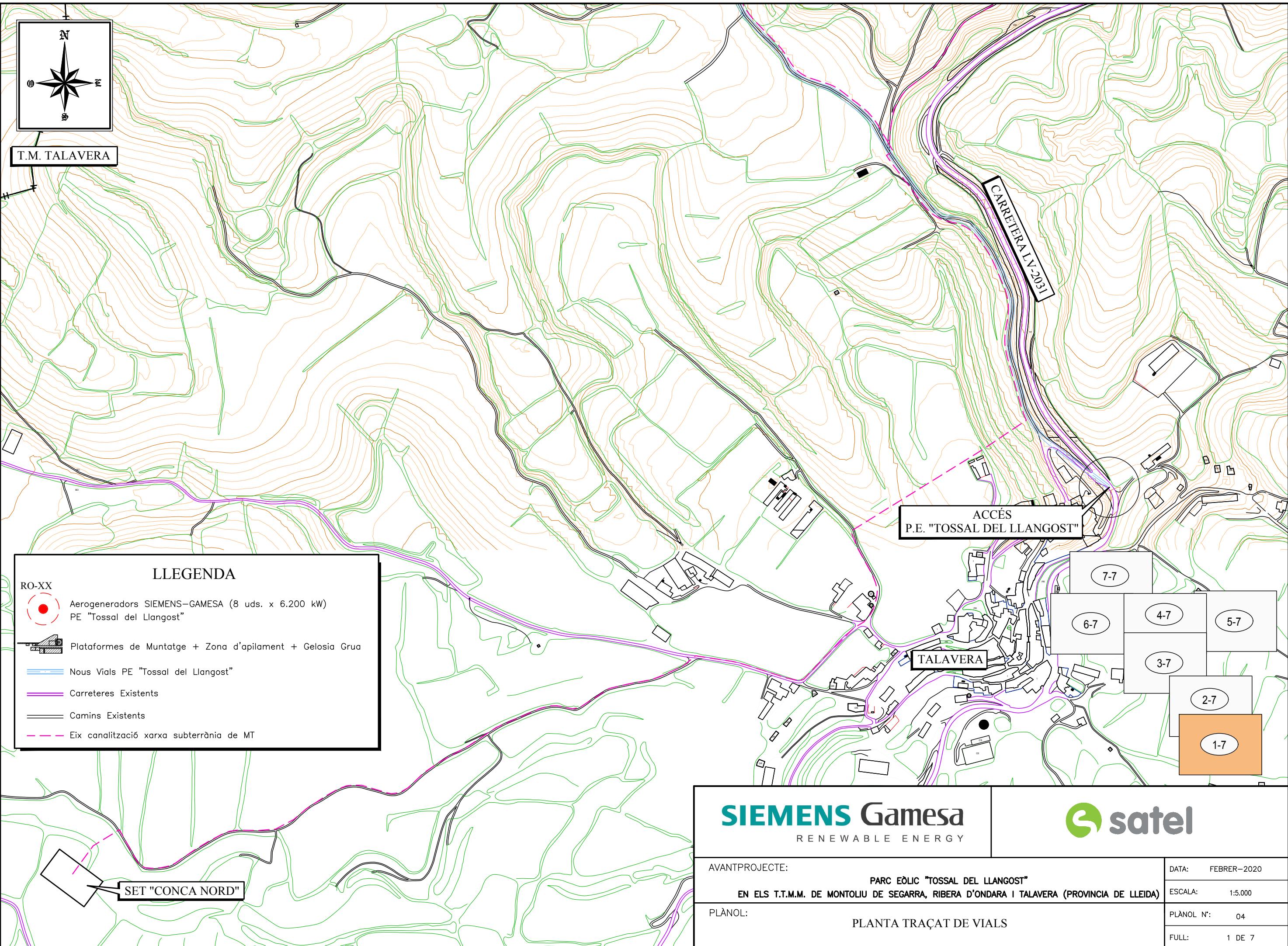
SITUACIÓ

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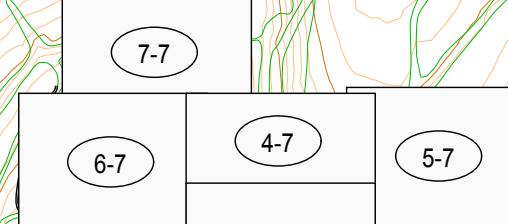




MAPA DE PLANTAS TRACAT DE VIALS

LLEGENDA

- RO-XX Aerogeneradors SIEMENS-GAMESA (8 uds. x 6.200 kW)
PE "Tossal del Llangost"
- Plataformes de Muntatge + Zona d'apilament + Gelosia Grua
- Nous Vials PE "Tossal del Llangost"
- Carreteres Existents
- Camins Existents
- Eix canalització xarxa subterrània de MT



SIEMENS Gamesa
RENEWABLE ENERGY

 **satel**

AVANTPROJECTE:

PARC ÈOLIC "TOSSAL DEL LLANGOST"
EN ELS T.T.M.M. DE MONTOLIU DE SEGARRA, RIBERA D'ONDARA I TALAVERA (PROVINCIA DE LLEIDA)

DATA: FEBRER-2020

ESCALA: 1:5.000

PLÀNOL:

PLANTA TRACAT DE VIALS

PLÀNOL N°: 04

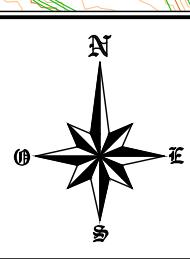
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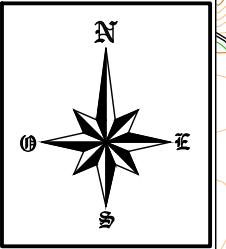
T.M. RIBERA
D'ONDARA

T.M. MONTOLIU
DE SEGARRA

T.M. TALAVERA

CARRETERA LV-2031





T.M. RIBERA
D'ONDARA

RO-2

RO-1

LLEGENDA

RO-XX

Aerogeneradors SIEMENS-GAMESA (8 uds. x 6.200 kW)
PE "Tossal del Llangost"

Plataformes de Muntatge + Zona d'apilament + Gelosia Grua

Nous Vials PE "Tossal del Llangost"

Carreteres Existents

Camins Existents

Eix canalització xarxa subterrània de MT

T.M. MONTOLIU
DE SEGARRA



SIEMENS Gamesa
RENEWABLE ENERGY

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EN ELS T.T.M.M. DE MONTOLIU DE SEGARRA, RIBERA D'ONDARA I TALAVERA (PROVINCIA DE LLEIDA)

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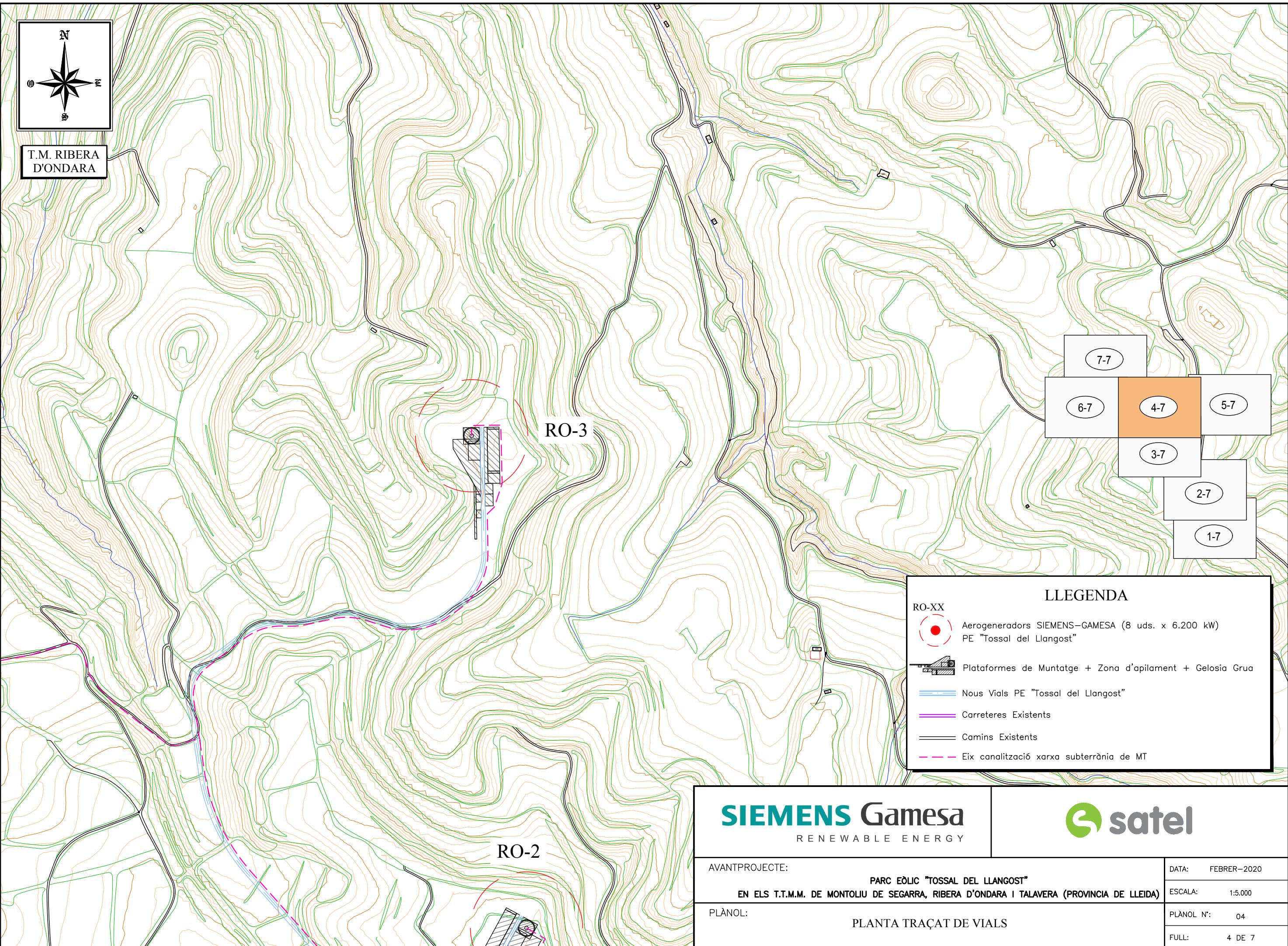
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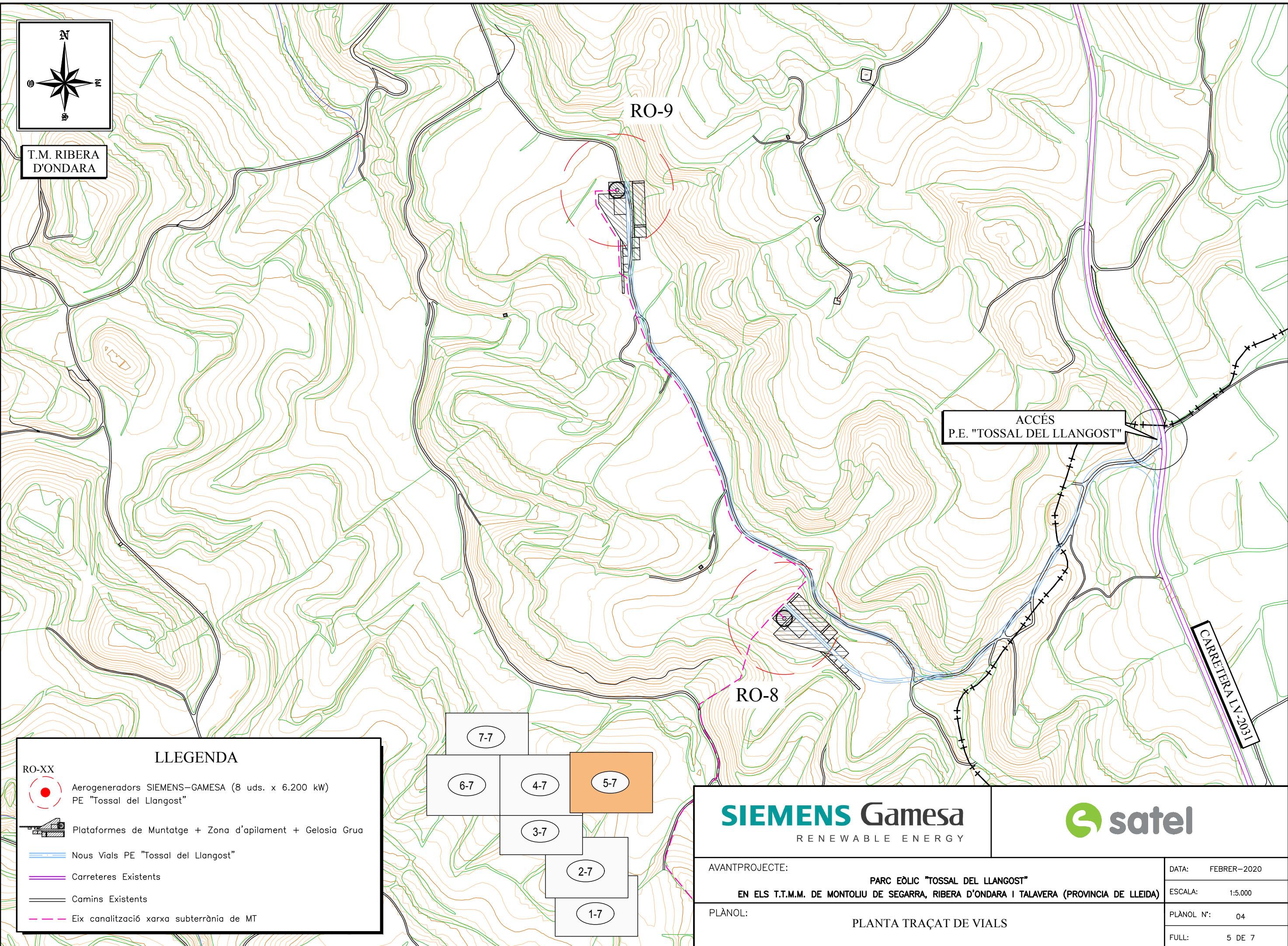
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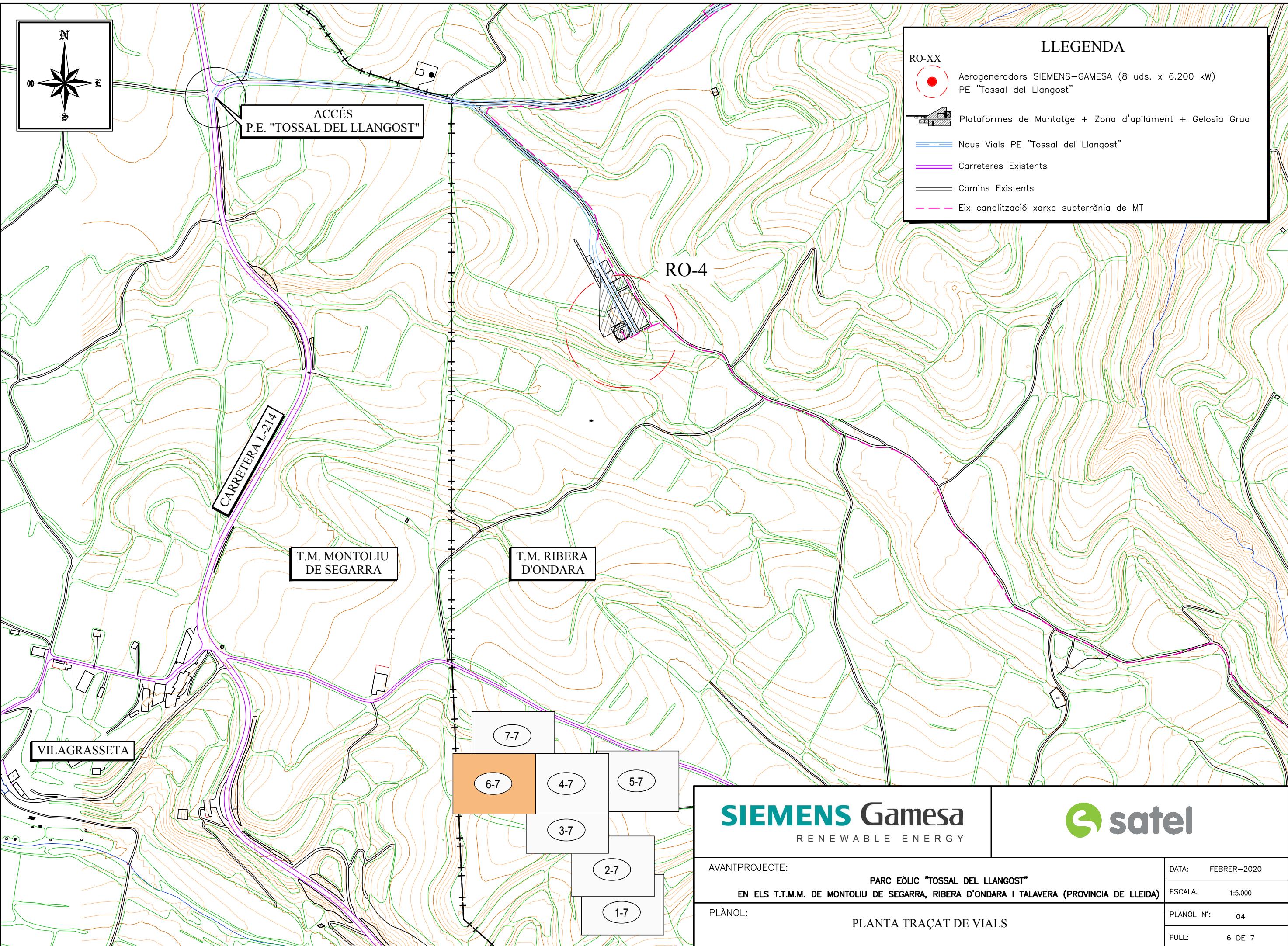
PLANTA TRAÇAT DE VIALS

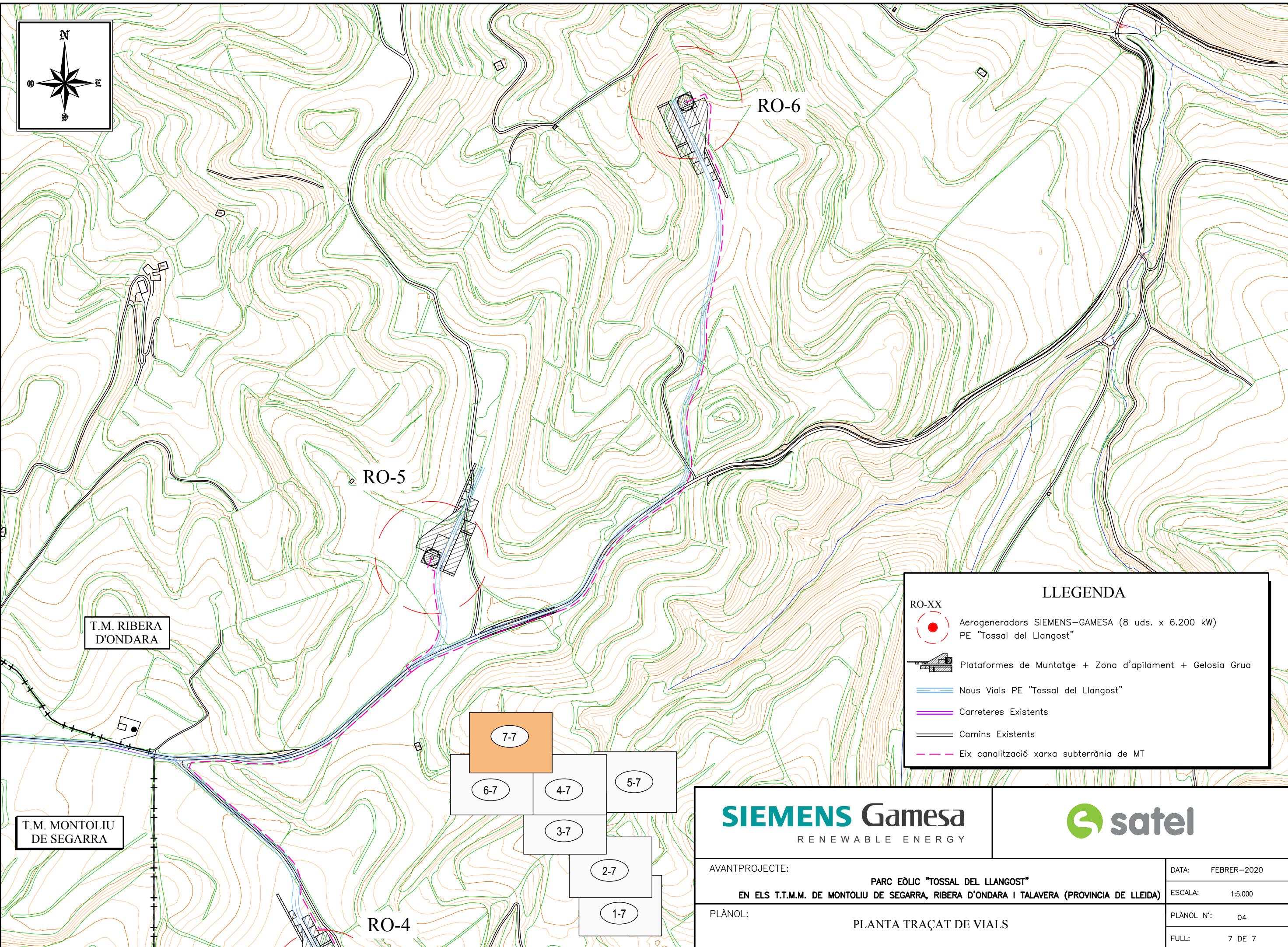
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FULL: 3 DE 7

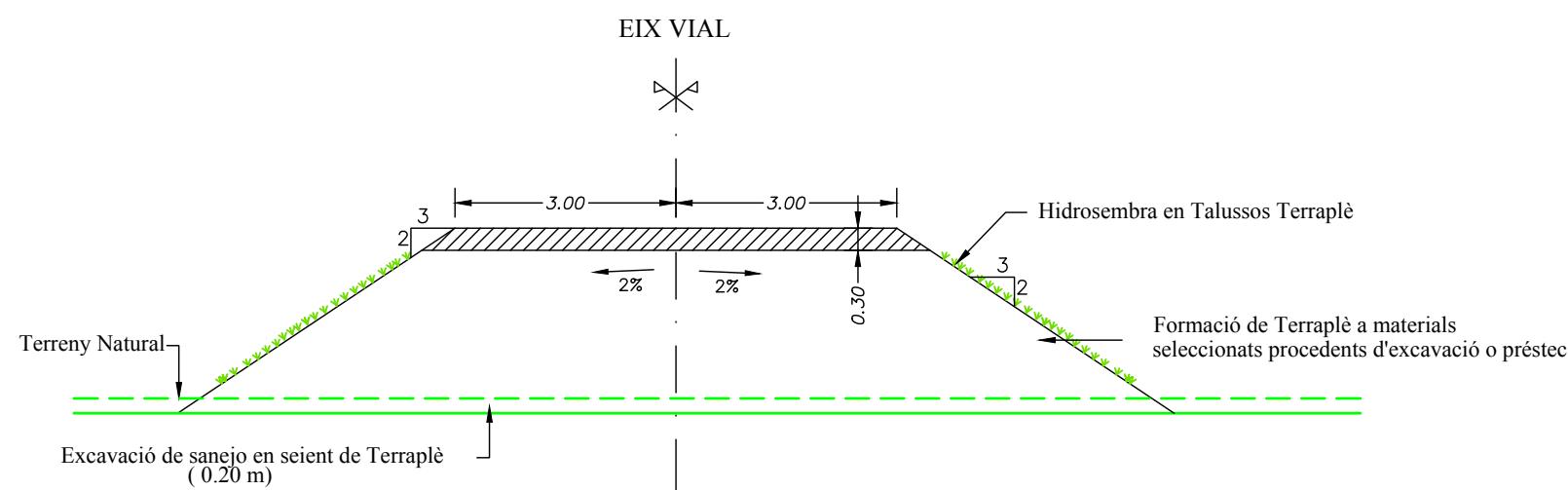




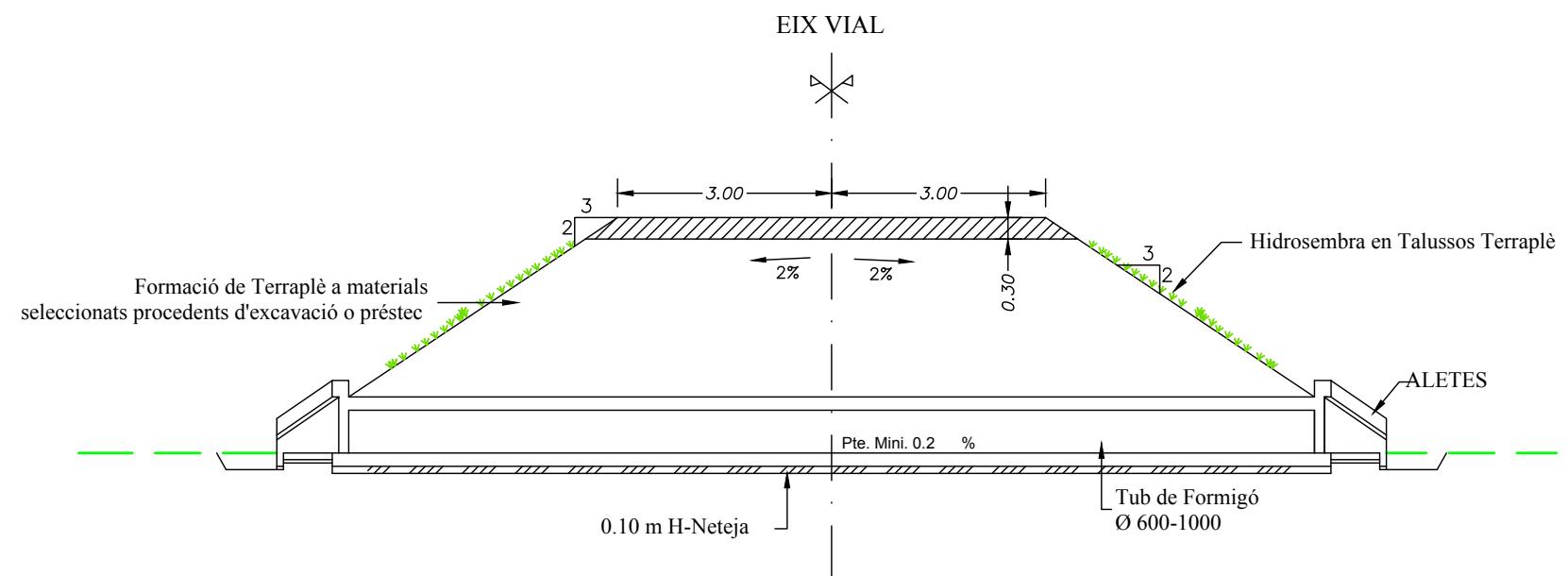




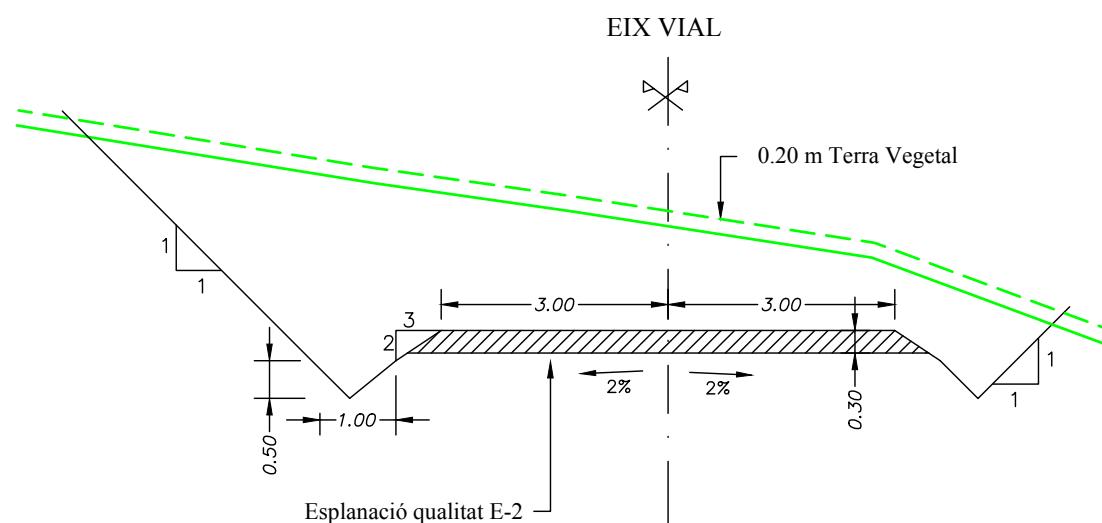
SECCIÓ TIPUS VIAL EN TERRAPLÈ



SECCIÓ TIPUS VIAL EN TERRAPLÈ
(SECCIÓ TIPUS AMB O.D.)
ALETES-ALETES



SECCIÓ TIPUS VIAL EN DESMUNT



FERMS

Base (0.30 m)
Ferm Artificial

SIEMENS Gamesa
RENEWABLE ENERGY

satel

AVANTPROJECTE:

PARC ÈOLIC "TOSSAL DEL LLANGOST"
EN ELS T.T.M.M. DE MONTOLIU DE SEGARRA, RIBERA D'ONDARA I TALAVERA (PROVINCIA DE LLEIDA)

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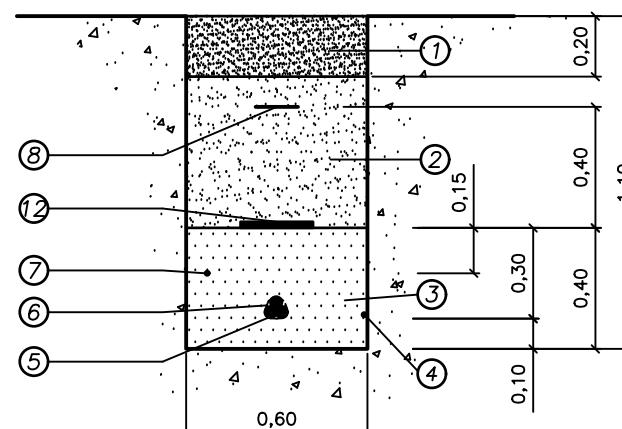
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SECCIÓ TIPUS DE VIALS

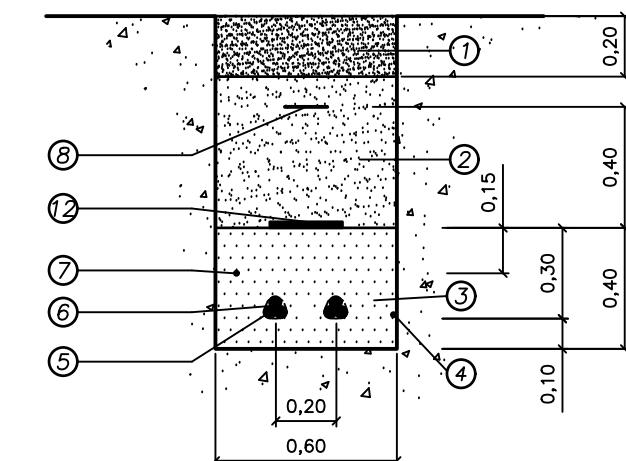
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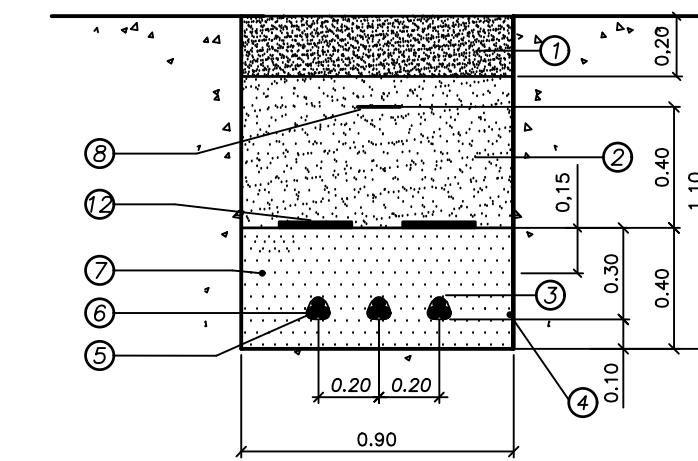
RASA PER A UN CIRCUIT



RASA PER A DOS CIRCUITS



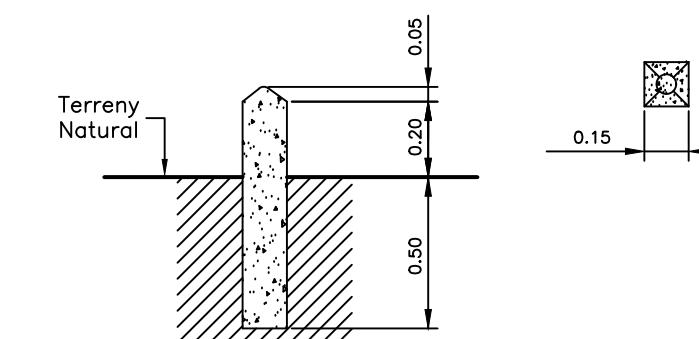
RASA PER A TRES CIRCUITS



FITA DE SENYALITZACIÓ

ALÇAT

PLANTA



-NOTA: EN CAMPS DE CULTIU, LES RASES SERAN DE 1.3 METRES DE PROFUNDITAT

12	PLACA PPC DE SENYALITZACIÓ DE POLIETILÈ SEGONS RU 0206
11	TUB DE PVC Ø90 SEGONS UNE 53112
10	TUBS DE PVC Ø200 SEGONS UNE 53112
9	FORMIGÓ EN MASSA HM-20
8	CINTA DE POLIETILÈ PER A SEÑALITZACIÓ
7	CABLE DE FIBRA ÒPTICA
6	ABRAÇADORA TIPUS UNEX (COL·LOCADA CADA 1.50 m)
5	TERNA DE CABLES UNIPOLARS DE M.T.
4	CABLE DE POSADA A TERRA. 50 mm ² Cu.
3	SORRA TAMISADA o RENTADA DE RIU AFLIXADA Y ASPRA
2	TERRA D'EXCAVACIÓ DEGUDAMENT COMPACTADA
1	TERRA VEGETAL
Marca	D e n o m i n a c i ó

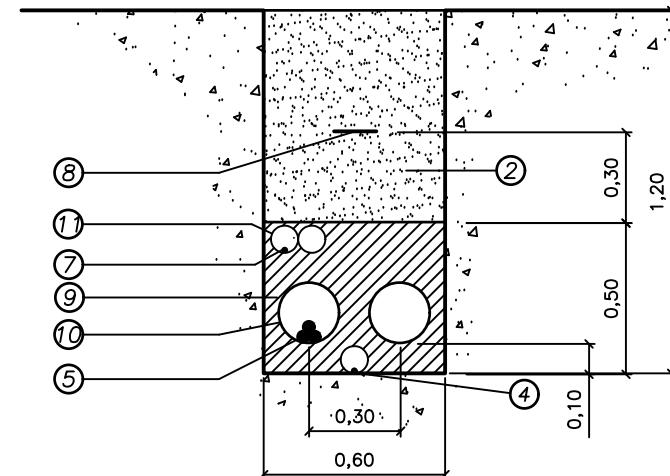
- LES FITES ANIRAN SITUADES CADA 50 M EN ELS CANVIS DE DIRECCIÓ DE LES RASES I MARCANT ENTRONCAMENTS
- LES FITES ANIRAN PINTADES (GROC DIRECCIÓ, VERMELL EN ENTRONCAMENTS)
- LA F.O. ANIRÀ PEL COSTAT ESQUERRE DE LA XARXA, DE FINAL DEL CIRCUIT A LA SET

SIEMENS Gamesa
R E N E W A B L E E N E R G Y

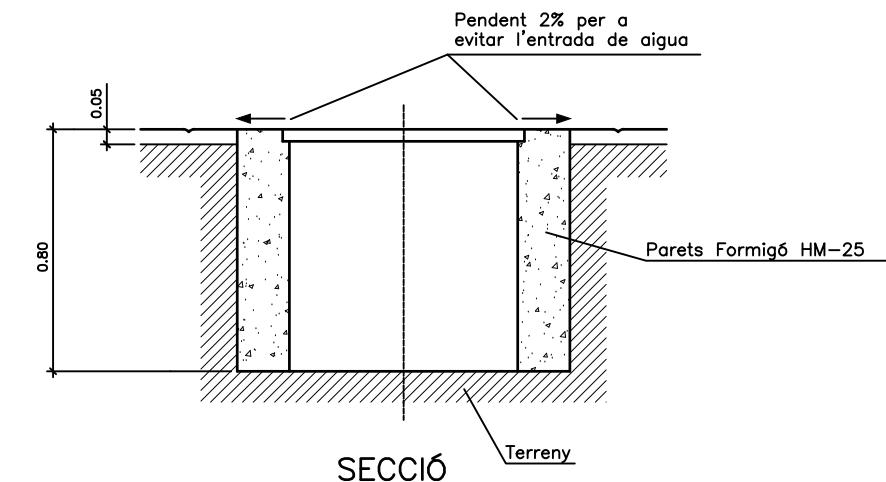
satel

AVANTPROJECTE:	DATA:	FEBRER-2020
PARC ÈOLIC "TOSSAL DEL LLANGOST"		
EN ELS T.T.M.M. DE MONTOLIU DE SEGARRA, RIBERA D'ONDARA I TALAVERA (PROVINCIA DE LLEIDA)	ESCALA:	1:25
PLÀNOL:	PLANOL N°:	6
RASES TIPUS	FULL:	1 DE 2

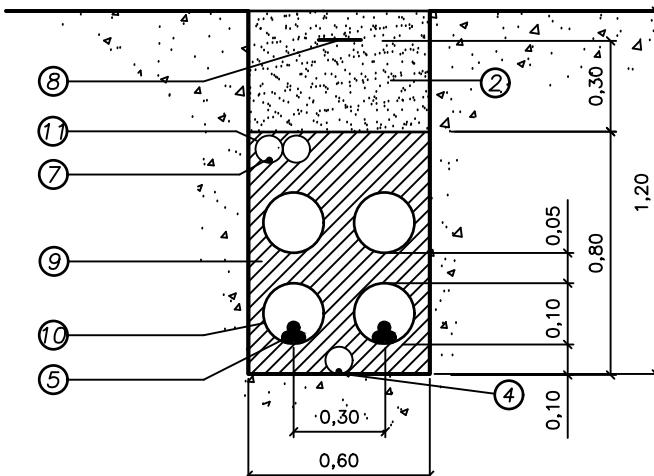
RASA DE CRUÏLLA PER A UN CIRCUIT



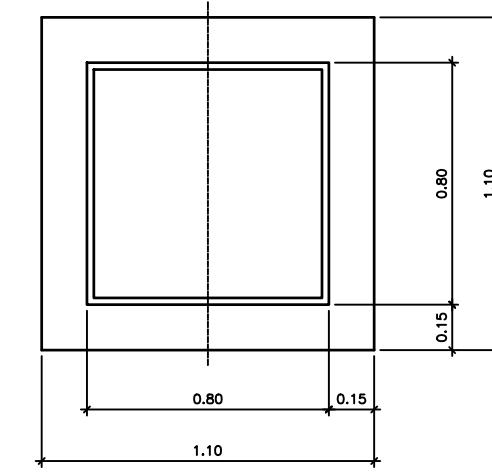
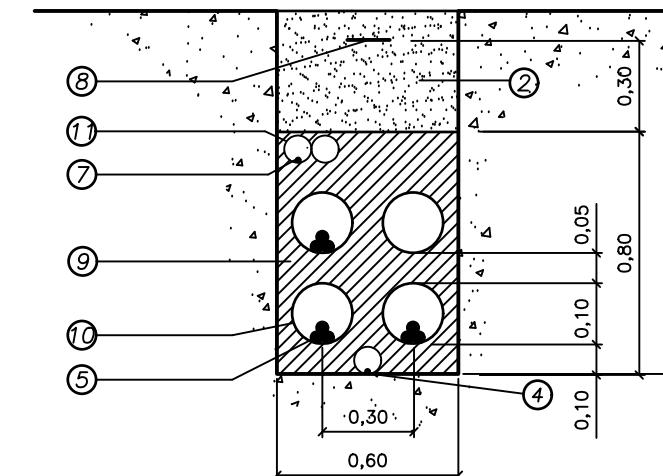
ARQUETA TIPUS



RASA DE CRUÏLLA PER DOS CIRCUITS



RASA DE CRUÏLLA PER A TRES CIRCUITS



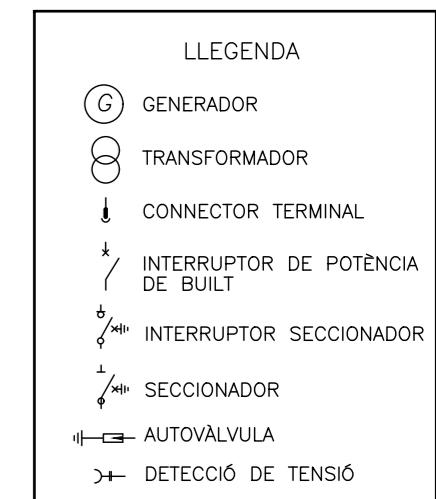
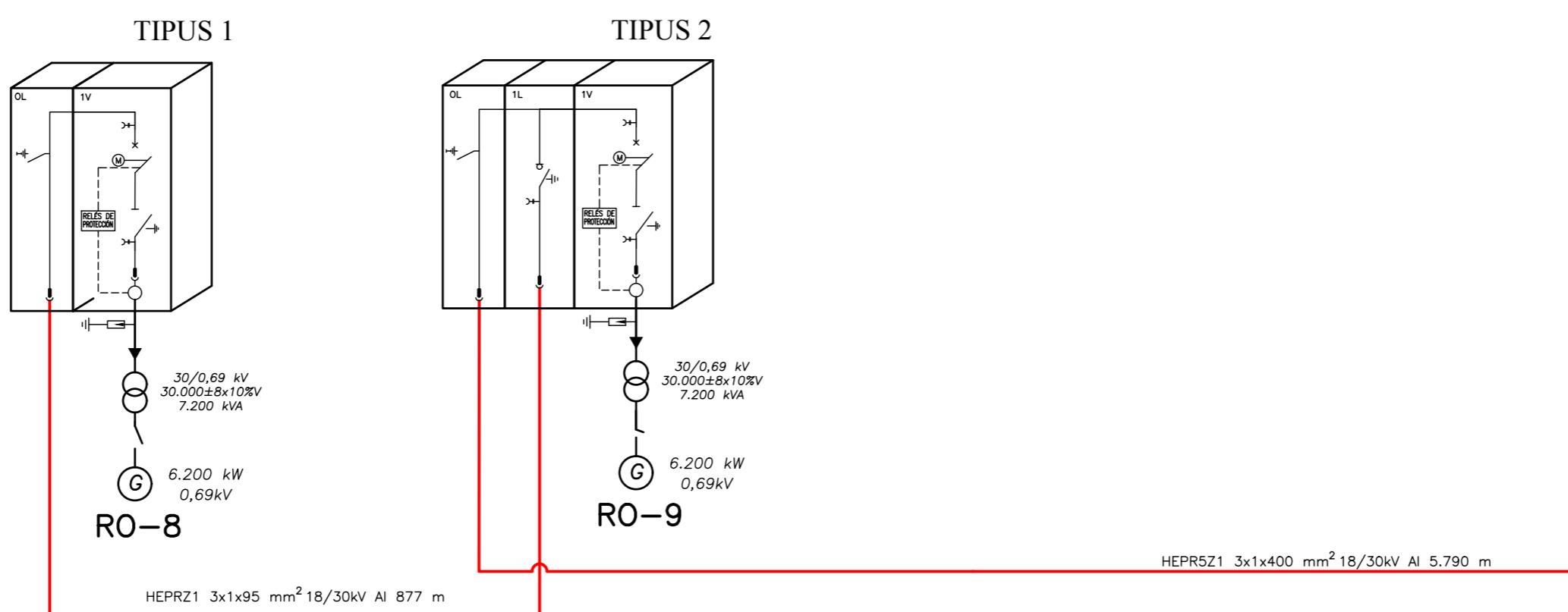
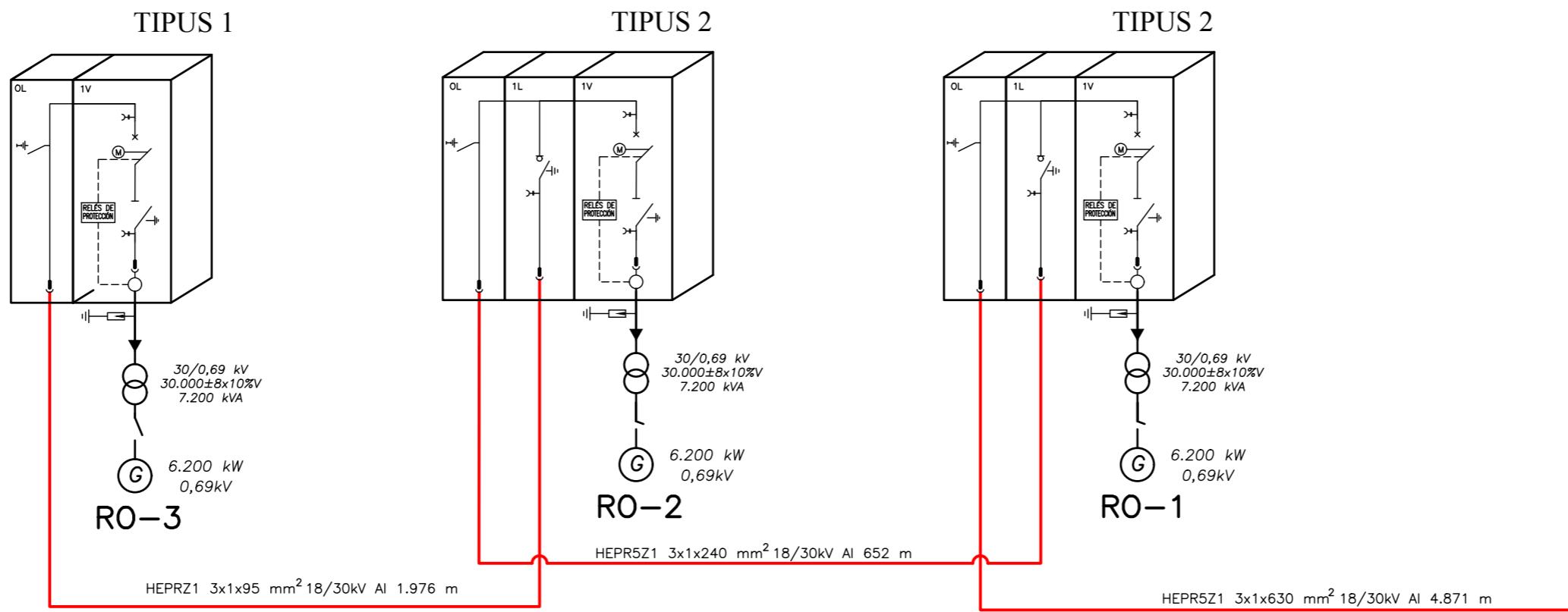
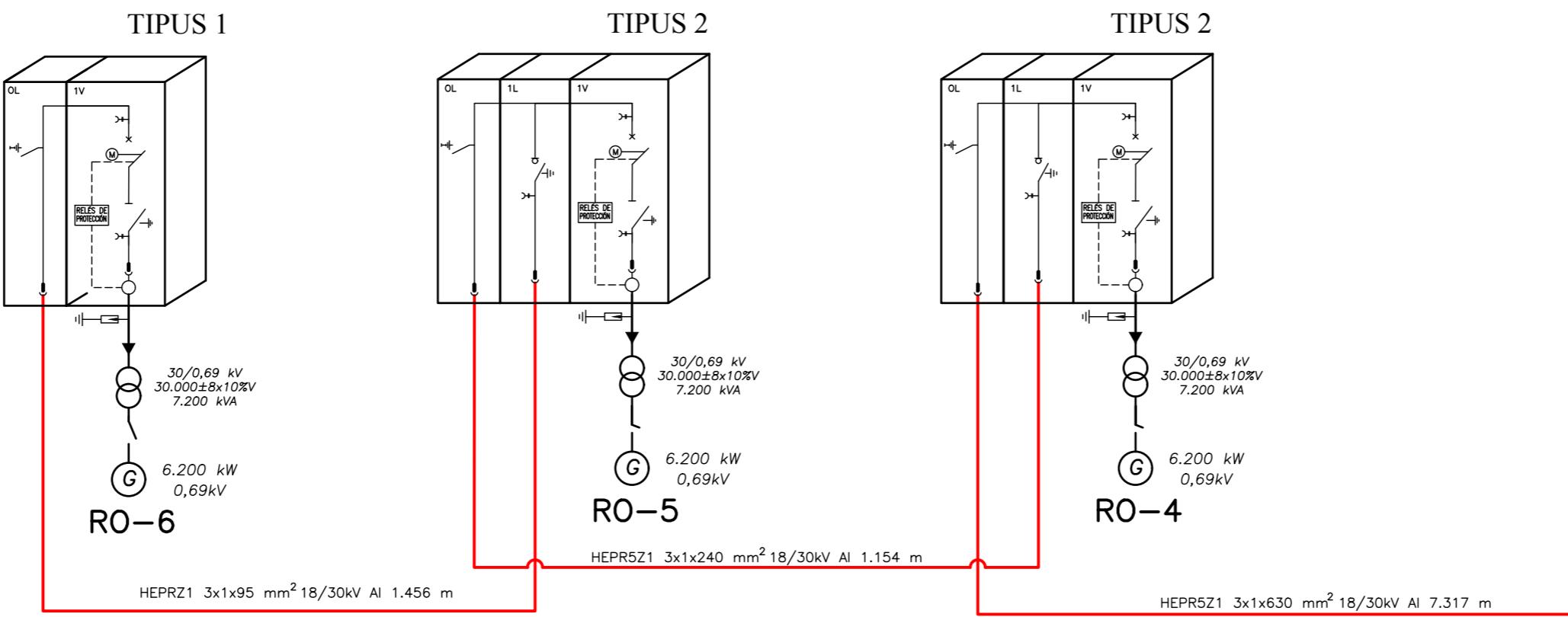
PLANTA

12	PLACA PPC DE SENYALITZACIÓ DE POLIETILÈ SEGONS RU 0206
11	TUB DE PVC Ø90 SEGONS UNE 53112
10	TUBS DE PVC Ø200 SEGONS UNE 53112
9	FORMIGÓ EN MASSA HM-20
8	CINTA DE POLIETILÈ PER A SEÑALITZACIÓ
7	CABLE DE FIBRA ÒPTICA
6	ABRAÇADORA TIPUS UNEX (COL·LOCADA CADA 1.50 m)
5	TERNA DE CABLES UNIPOLARS DE M.T.
4	CABLE DE POSADA A TERRA. 50 mm ² Cu.
3	SORRA TAMISADA o RENTADA DE RIU AFLIXADA Y ASPRA
2	TERRA D'EXCAVACIÓ DEGUDAMENT COMPACTADA
1	TERRA VEGETAL
Marca	D e n o m i n a c i ó

SIEMENS Gamesa
RENEWABLE ENERGY

satel

AVANTPROJECTE:	DATA:	FEBRER-2020
PARC ÈOLIC "TOSSAL DEL LLANGOST"		
EN ELS T.T.M.M. DE MONTOLIU DE SEGARRA, RIBERA D'ONDARA I TALAVERA (PROVINCIA DE LLEIDA)	ESCALA:	1:25
PLÀNOL:		PLANOL N°: 6
RASES TIPUS		FULL: 2 DE 2

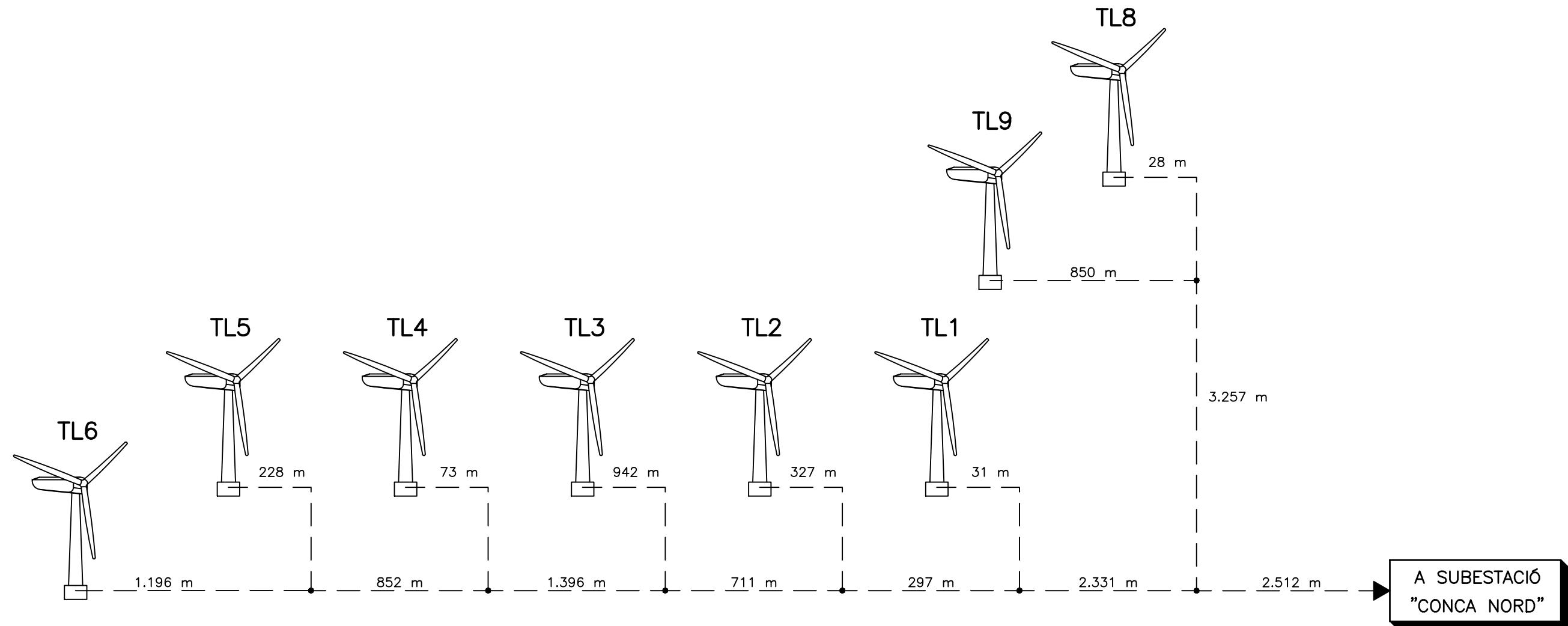


CEL·LES SF6:
Ur=33 kV Umax=36 kV
In=630 A
Is=20 kA, 1s
IAC: AFLR, 20 kA, 1s
Relé protecció: 50/51,50N/51N

SIEMENS Gamesa
RENEWABLE ENERGY

satel

AVANTPROJECTE:	DATA: FEBRER-2020
PARC ÈOLIC "TOSSAL DEL LLANGOST" EN ELS T.T.M.M. DE MONTOLIU DE SEGARRA, RIBERA D'ONDARA I TALAVERA (PROVINCIA DE LLEIDA)	ESCALA: S/E
PLÀNOL:	PLÀNOL N°: 7
UNIFILAR MT	FULL: 1 DE 1



CABLE DE POSADA A TERRA ————— 1x50 mm² Cu —————
SOLDADURA ALUMINOTÈRMICA •

SIEMENS Gamesa
RENEWABLE ENERGY

satel

AVANTPROJECTE:	DATA: FEBRER-2020
PARC ÈOLIC "TOSSAL DEL LLANGOST"	
EN ELS T.T.M.M. DE MONTOLIU DE SEGARRA, RIBERA D'ONDARA I TALAVERA (PROVINCIA DE LLEIDA)	ESCALA: S/E
PLÀNOL:	PLÀNOL N°: 08
XARXA DE TERRES MT	FULL: 1 DE 1