Llynfl Afan Renewable Energy Park

A ZIV successful turn-key solution for protection and automation, working with the main contractor, NRS GROUP, from Livingston (Scotland), GAMESA ENERGY UK LIMITED (GEUK) and WESTERN POWER DISTRIBUTION

1 INTRODUCTION: GENERAL DETAILS AND INVOLVED COMPANIES.

ZIV Grid Automation was awarded with the contract to provide a turn-key solution for protection and automation at **Llynfl Afan Renewable Energy Park**. Working with the main contractor, NRS GROUP, from Livingston (Scotland), GAMESA ENERGY UK LIMITED (GEUK) and WESTERN POWER DISTRIBUTION (WPD), ZIV Grid Automation applied 25 year experience contributing to bring this project into a successful end.

2 DESCRIPTION OF THE PROJECT.

Llynfl Afan Renewable Energy Park **consists of 12 GAMESA G80 wind turbines rated at 2MW each with a total installed capacity of 24MW**. Renewable energies continue to increase their market share of the generation sector, shaping how we approach generation, transmission and distribution. The site of this project is on land in Neath Port Talbot (NPTCBC), Bridgend (BCBC) and Rhondda Cynon Taff (RCTCBC) County Borough Councils, in South Wales.

The scope of supply for Llynfl Afan Renewable Energy Park constituted **complete SCADA interfaced substation monitoring, protection and networking equipment: MV Transformer protection and control cabinets with automatic voltage regulation and 33kV feeders**.

One substation was built to be the link between turbine array and distribution grid. A single busbar topology with 66/33kV step-up power transformer, reactive power compensation and interfaces with DNO as well as Wind Turbine manufacturers SCADA were required.

The main initial input to ZIV was the single line diagram in which the following elements were included in a 33kV busbar with the following inputs and outputs:

- An input of power from 6 wind turbines (T2 to T8) connected in a serial array.
- A double input of cables for two serial arrays, one of them for two wind turbines (T14 and T13) and a second serial array for the final 4 wind turbines (T15, T12, T10 and T11).
- An output for the Auxiliary Services Transformer (33kV/400V 50kVA).
- An output for a Reactive compensation (Capacitive) system.
- An output to the power transformer 66/33kV 22/26MVA that will connect the busbar directly to the WPD grid.

*See the single line diagram of the substation in the appendix of this document

3 DESCRIPTION OF THE SOLUTION.

The design of the protection, control and substation automation system was done focusing on meeting and exceeding project requirements, capturing direct client, wind turbines manufacturer and DNO specifications, and always considering the technical guidance given in the G59 specification.

With electrical design and logic engineering consultancy services ZIV Grid Automation ensured a **seamless, interoperable and G59 licensed solution, based on in-house designed and manufactured IED's, fully ready for operation at client handover.**

3.1 ELEMENTS AND RELAYS INVOLVED IN THE SOLUTION:

The solution presented for the system involved elements that can be divided in 3 categories:

- In one hand, the IEDs for protection and control of the 33kV arrays of wind turbines, the IEDs to protect, control and perform automatisms in the Reactive Compensation equipment and the protection and control of the Auxiliary Services breaker.
- On the other hand, a self-standing swing rack panel with the protections and controls for the power transformer.
- Finally, a self-standing swing rack panel with all the elements related to the substation automation and the networking elements.
-



IRX O/C Multifunction Feeder Protection

6RTV - Automatic Voltage Controller and tap changer for up to 5 parallel transformers

The solution for the protection and control of the elements located in the 33kV switchgears were sent independently to the switchgear.

P+C+M EQUIPMENT FOR LLYNFI AFAN			
Code	**Protection/ control functions**	**Make**	**Model**
Substation Automation System (SAS) (2200x800x800)			
HMI	Local Touchscreen HMI	CINCOZE	CV-117
GW	Substation Gateway model CPT	ZIV	1CPTC1A250020FAL
GPS	GPS synchronization device	ARBITER	1094B
BCU	Control device for auxiliary service signals	ZIV	7IRVJ3F2209A6VMM
SW	Rack Mounted Ethernet IEC61850 comm.s switch	ZIV	3SWTEE001NM300AM
AAL	SAS Alarm Modem	ZIV	4MDUG1001010008A
Protection, Control and Metering panel for 66/33kV Transformer (2200x800x800)			
P1	Numerical Differential protection Relay, IED Model 8IDV	ZIV	8IDVL3F2C0ED6QNL
P2	66kV side Numerical Bay Control Unit + backup protection, Model 7IRV	ZIV	7IRVJ3F22S7A6QMM
AVR	Automatic voltage regulator	ZIV	6RTVP3N22S4A6SML
P3	33kV side backup protection, model 8IRV	ZIV	8IRVJ3F22Y1A6SML
SW	DIN-rail Mounted Ethernet IEC61850 communications switch	ZIV	3SWTA00N1NMW000C
Loose equipment to be installed in 33kV switchgear cabinet			
P1	33kV bays BCU + protection, model 2IRX	ZIV	2IRXB6N2241F0GLL
P1	33kV Capacitor Bank protection, model 7BCV	ZIV	7BCVE3F22U316QNL
P2	33kV Capacitor Bank Power Quality and Revenue Meter, model SEL-735	SEL	SEL735-
SW	DIN-rail Mounted Ethernet IEC61850 communications switch	ZIV	3SWTA00N1NMW000C

Following there is a short description of reach one of the elements mentioned in the chart above. Any detailed information is available in technical manuals, brochures and flyers available on demand or directly from the web site (www.ziv.es)

8IDV-L3F, Transformer differential protection

IDV relays include all protection, control and measurement functions for two or three winding transformers and autotransformers at any voltage level, with single or double breaker. It may also be applied as differential protection in reactance's, generators or motors. Its quick action differential element, together with leading edge blocking and harmonic restraint and external fault detection provides great reliability under all conditions.

At Llynfi Afan wind turbine array the 8IDV handles 66/33kV transformer protection covering HV side inverse/instantons overcurrent protection (50/51), differential (87T) and Balance Earth Fault (BEF) protection, as well as a thermal overload protection (48) and pressure switch functions (63) to protect this important asset. A fault recorder logs event data. These are a small fraction of the 8IDVs capability [insert: more examples of protection function

8IRV-J3F, multi protection & control

The IED generically called IRV integrates protection, control and metering functions for a great variety of applications, such as feeders, machine lines, frontier points, etc. These IEDs use the most advanced digital technology based on a potent microprocessor and DSPs that incorporate Directional and Non-Directional Overcurrent Protection, Overvoltage, Undervoltage, Over / Underfrequency, Synchronism, Power Inversion, Thermal Image, Recloser function and others.

At Llynfi Afan, this relay is used for the transformer secondary functions like HV Overcurrent Protection (50/51), U/O Voltage (59, 27), Frequency functions (81M, 81m, 81 ROCOF), Fault recorder, are provided by this protection relay.

7IRV-J3F, multi protection & control

Apart of the characteristics mentioned in the device above, the 7IRV incorporates a graphical display type LCD with size 114 x 64 mm (240 x 128 pixels It is provided with own illumination and include five keys with functions to manage the full bay.

At Llynfi Afan, this relay is acting as Bay Control Unit of the complete Transformer Bay, with mimic HMI while providing LV protection to the transformer: LV Overcurrent Protection (50/51), U/O Voltage (59, 27), Frequency functions (81M, 81m, 81 ROCOF), Fault recorder

6RTV-P3N, Transformer Voltage Controller

The generic name RTV groups equipment that include tap changer control functions for power transformer voltage regulation. This is leading-edge technology based on powerful microprocessors and DSP's.

RTV systems are used in applications where constant voltage level must be maintained without service interruption. Voltage is regulated from voltage and current measurements at power transformer terminals through current transformers (CTs) and voltage transformers (VTs), sending command signals to the applicable transformer tap changer to raise or lower the voltage to set-point value

2IRX Protection and Control in MV switchgear.

The IED generically called IRX integrates protection, control and metering functions for a great variety of applications, such as feeders, machine lines, frontier points, etc. These IEDs use the most advanced digital technology based on a potent microprocessor and DSPs that incorporate Directional and Non-Directional Overcurrent Protection, Overvoltage, Undervoltage, Over/Underfrequency, Synchronism, Power Inversion, Thermal Image, Recloser function and others.

At Llynfi Afan, these relays were installed in the MV switchgear, to protect the wind turbines feeders, the transformer incomer and the Auxiliary Services Transformer

7BCV, Bank capacitor Control and protection

The IED generically called BCV integrates protection, control and metering functions for a great variety of applications. BCV systems are designed applicable to Capacitor or Reactor Banks and feeders in general where a protection, control and measurement device is required.

At Llynfi Afan, the 7BCV was installed in the bank capacitor cabinet of the MV switchgear.

CPT, (Gateway + RTU) Substation Control Unit.

CPT IEDs, together with Level 1 protection and control devices, are part of the Integrated Substation Protection and Control System (SIPCO), operating both as Substation Central Unit (UCS) with Integrated WEB Console and remote control terminal (RTU).

Among the general functions of the CPT are the following: communication with Level 1 equipment (protection and control devices in the substation), integration of all substation control information in a common real-time database, communication with equipment of the same or higher level with protocol emulation (DNO and Wind Turbines SCADA), execution of programmable control functions at the substation level and ability to execute manouvres with interlocking management at the substation level.

7IRV Model, for Auxiliary signals

Another unit as the one described above was used for the integration of the auxiliary services into the Substation Automation system

3SWT Ethernet Switches

A group of 3 ethernet switches, model 3SWT, designed and manufactured by ZIV were included in the project to build the communications network system inside the substation.

The 3SWT is a Layer 2 switch, with all the IEC61850 tests passed in third party laboratories, with multiple possibilities of types and number of Ethernet ports.

GPS synchronization device, with antenna and cable.

In order to ensure a correct treatment of all the data of the substation in the event and alarms of the Substation Automation, the IEDs must be properly time synchronized.

Substation Automation HMI

By means of a PC, the substation can be fully controlled from the Substation Control room. The PC installed in Llynfi Afan substation does not include any software installed. It gathers all the information from the web server embebbed in the Substation Central Unit (CPT) and allows the user to visualize graphically the status of all elements of the substation, to check the alarms and events of the complete system, and visualize the measurements of all the magnitudes in the substation.

The particular HMI screen prepared for the substation at Llynfi Afan are presented in this document.

3.2 SYSTEM ARCHITECTURE.

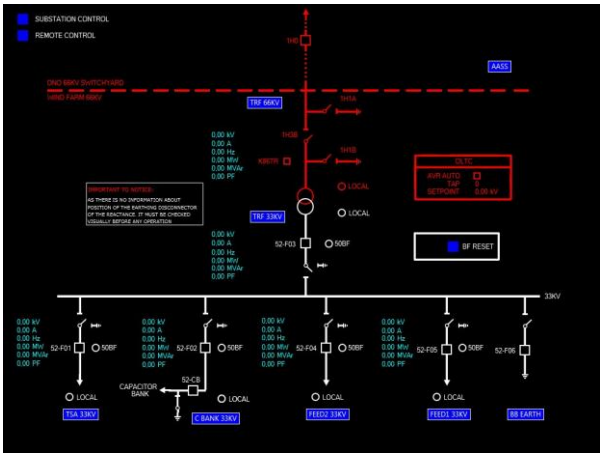
The standard that was followed, as requested in the specification, was the IEC61850. According to it, it was built a system architecture with an Ethernet ring in Fiber Optics between the switches included in the system. Each one of the protection an control elements were introduced into this network by single connections CAT5 ethernet cables.

*See the system architecture of the substation in the appendix of this document

3.3 SUBSTATION AUTOMATION HMI.

The following are examples of the HMI screens that can be seen in the Substation Automation PC in the Control Room. This information is also available in other PC outside of the substation if the proper communication systems are built.

Fig 1. General scheme of the substation &. Auxiliary transformer and diesel generator connection



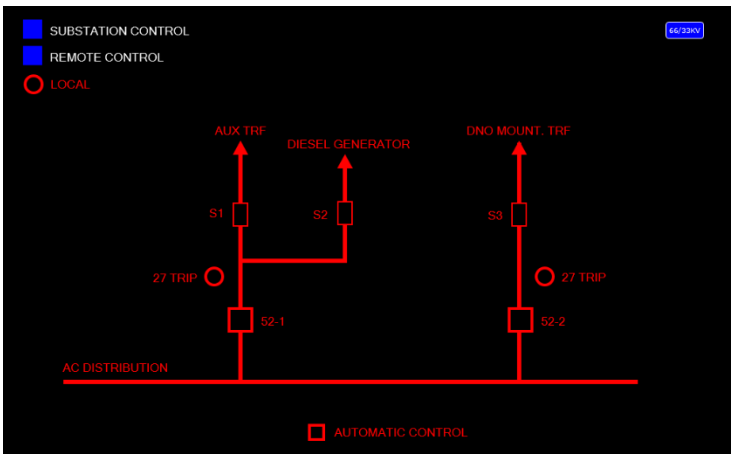
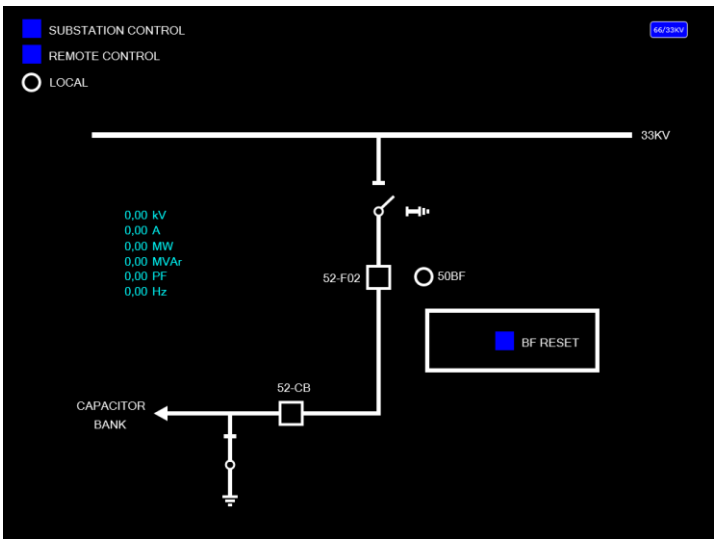


Fig 2. Bank Capacitor connection (left) and Feeder for the wind turbines connection (right)



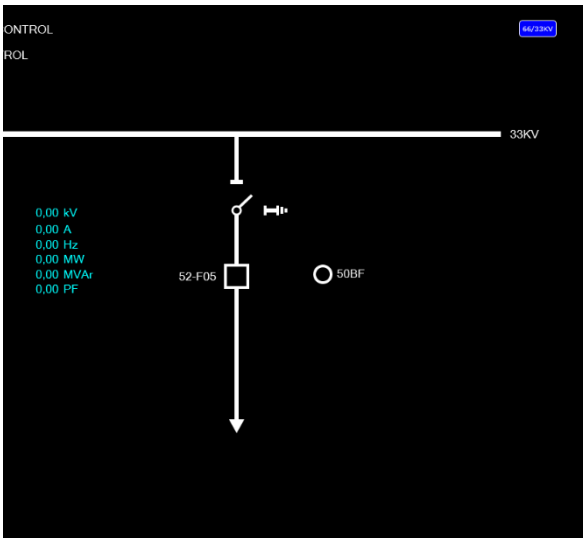
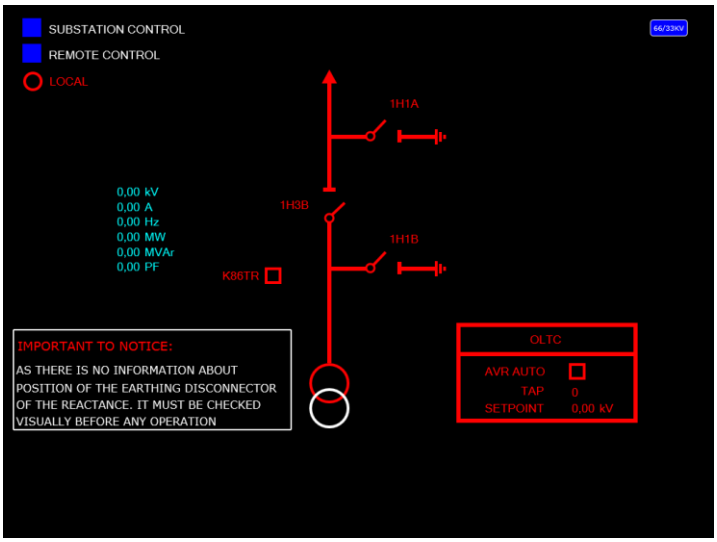


Fig 3. Transformer connection:



3.4 PANEL DRAWINGS

ZIV included in the project the panels that were necessary to hold the IEDs not to be installed in the MV swithchgear. They were self standing swinging rack panels with all elements and auxiliaries installed and wired in Zamudio, Spain. Also conventional control command boxes with switches and lamps for breakers controls, the panels for the auxiliary services and the marshaling kiosks were manufactured by ZIV.

*See the Autocad Drawings of the panels of the substation in the appendix:

3.5 PICTURES OF THE SUBSTATION.

3.6 COMMISSIONING DETAILS.

The commissioning was done in the following steps:

- Pre-commissioning: ZIV attended the substation Site together with the clients technicians to ensure all the logics were loaded and the system was ready for operation.
- Tests with the DNO. Together with WPD, the G59 relays were tested as per the forms to be followed in this standard.
- Grid connection: ZIV was present for any last minute requirement in the substation connection to the WPD network.

These steps were done as per requirement of the client and the owners of the project. The steps can be simplified or reduced in further opportunities.

The following are parts of the G59 protocol filled during the SAT:

2/2/17

ENA Engineering Recommendation G59
Issue 3 Amendment 2 2015
Page 105

LLYNFI AFAN FOR 2

Over and Under Voltage Protection Tests HV
referenced to 110V ph-ph VT output

Calibration and Accuracy Tests

Phase	Setting	Time Delay	Pickup Voltage				Time Delay measured value plus or minus 2V				
Stage 1 Over Voltage			Lower Limit	Measured Value	Upper Limit	Result	Test Value	Lower Limit	Measured Value	Upper Limit	Result
L1 - L2	121V 110V VT secondary	1.0s	119.35	122.11 (70.50)	122.65	Pass/~~Fail~~	Measured value plus 2V	1.0s	1.018	1.1s	Pass/~~Fail~~
L2 - L3				122.11 (70.50)		Pass/~~Fail~~			1.018		Pass/~~Fail~~
L3 - L1				122.11 (70.50)		Pass/~~Fail~~			1.019		Pass/~~Fail~~

Note: Full document available on demand

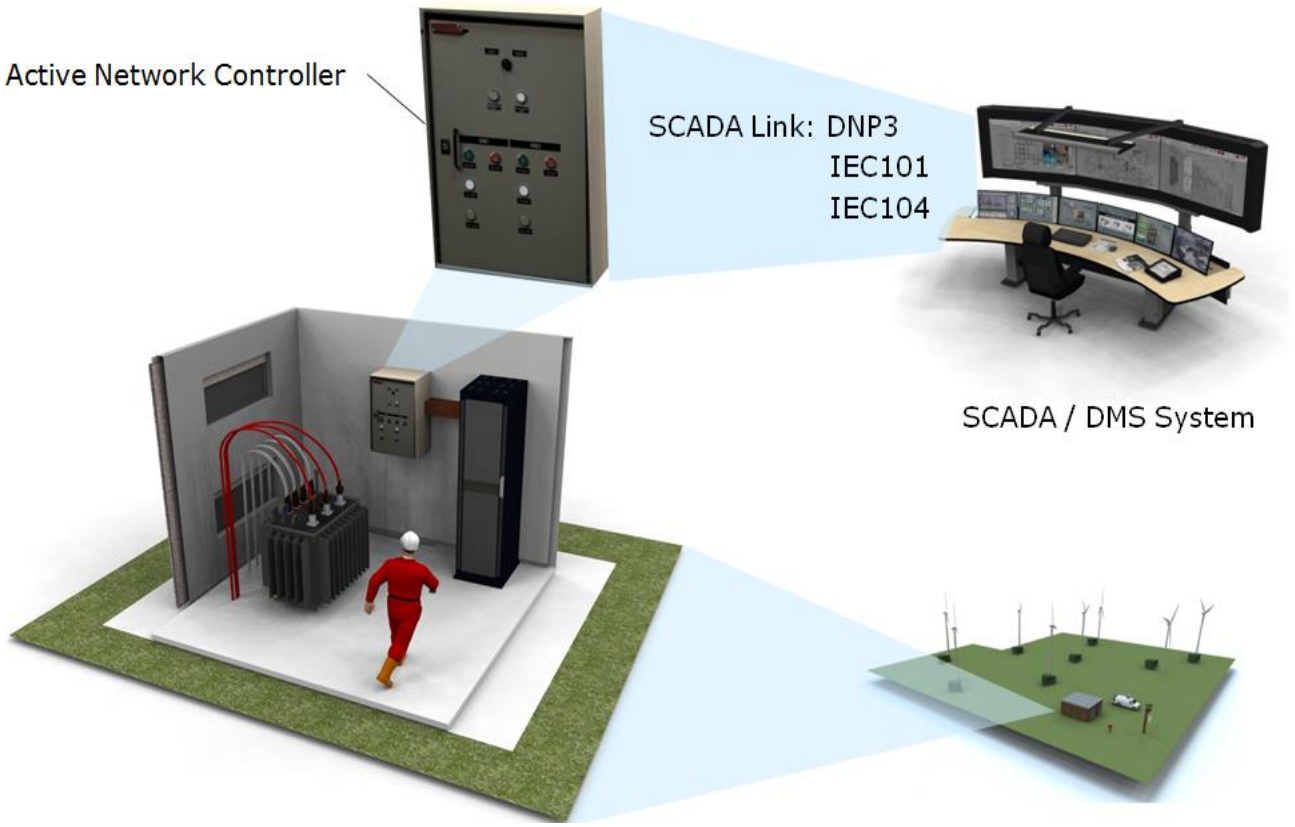
3.7 FURTHER SCOPE: ANM SYSTEM FOR DER INTEGRATION.

ZIV also provided an Automation solution for WPD´s Soft Inter-tripping System (SIS) that provides online and detailed knowledge of the whole MV and LV grids, from home users to Secondary Substations. It consists of smart cabinet containing a USP 2.0 RTU and a BCC battery charger.

BENEFITS: The purpose of the SIS is to provide both Remote (from SCADA) and Automatic (Local) control of a Generating Unit depending on the voltage conditions of the MV Network, monitored by a centralised system.

THREE OPERATING MODES: The SIS has three Operating Modes, Local, Remote and Automatic Mode, and two different stages. The two stages differ on the level of reduction of generation. In stage 1 the reduction is a percentage and in stage 2 is zero, which curtails the generation totally.

In Local Mode, the operator can Enable and Disable the Automation Mode and manually enable and disable the two different stages, using the pushbuttons of the SIS. In Remote Mode, all the pushbuttons are disabled. The operator can Enable and Disable the Automation Mode and remotely enable and disable the Stages from the NMS via the SCADA protocol. In Automatic Mode the SIS Controller can automatically enable and disable the Stages based on their algorithm.



4 CONCLUSSIONS

Conclusions and how we met and exceed our responsibility

The main conclusion taken after the finalization of this project is that ZIV is fully capable of building a substation automation and protection system for new connections to the DNO of renewable energy or other kind of systems.

ZIV has shown to comply with all the required standards and is capable of being a partner in projects of this kind with the ICPs in UK.

5 STANDARDS

The following standards have been followed to design and build the Protection, control and substation automation system of Llynfi Afan

ENATS_48-5_Issue3: Environmental test requirements for protection and control equipment and systems.

ENA_TS_48-6 Technical specifications for all the relevant protection functions existing in the substation.

ENA_ER_G59_3_3: Engineering Recommendation G59 for the connection of Generating plants to the distribution System of Licensed DNO

6 APPENDIX

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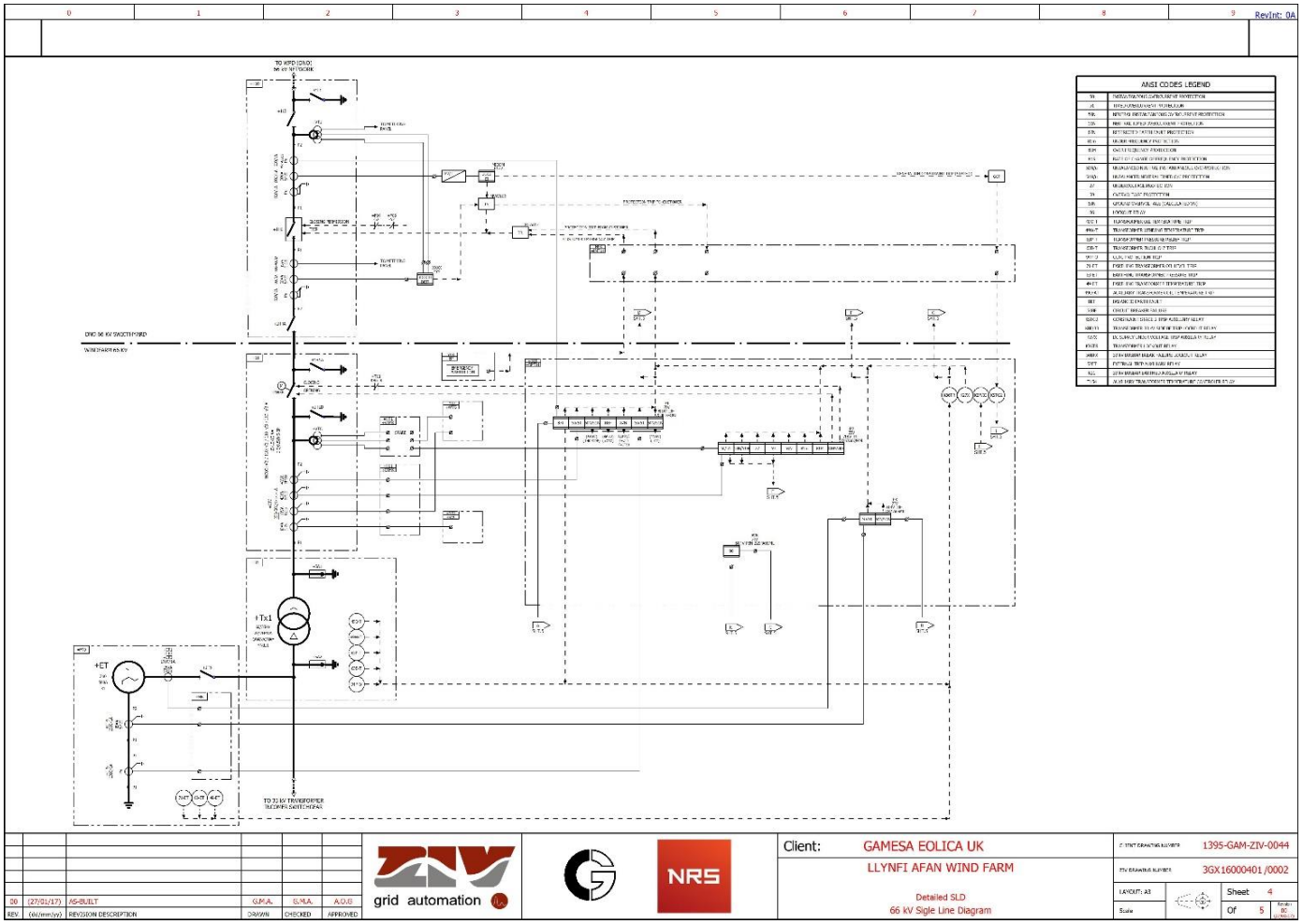
Single line diagram of the substation



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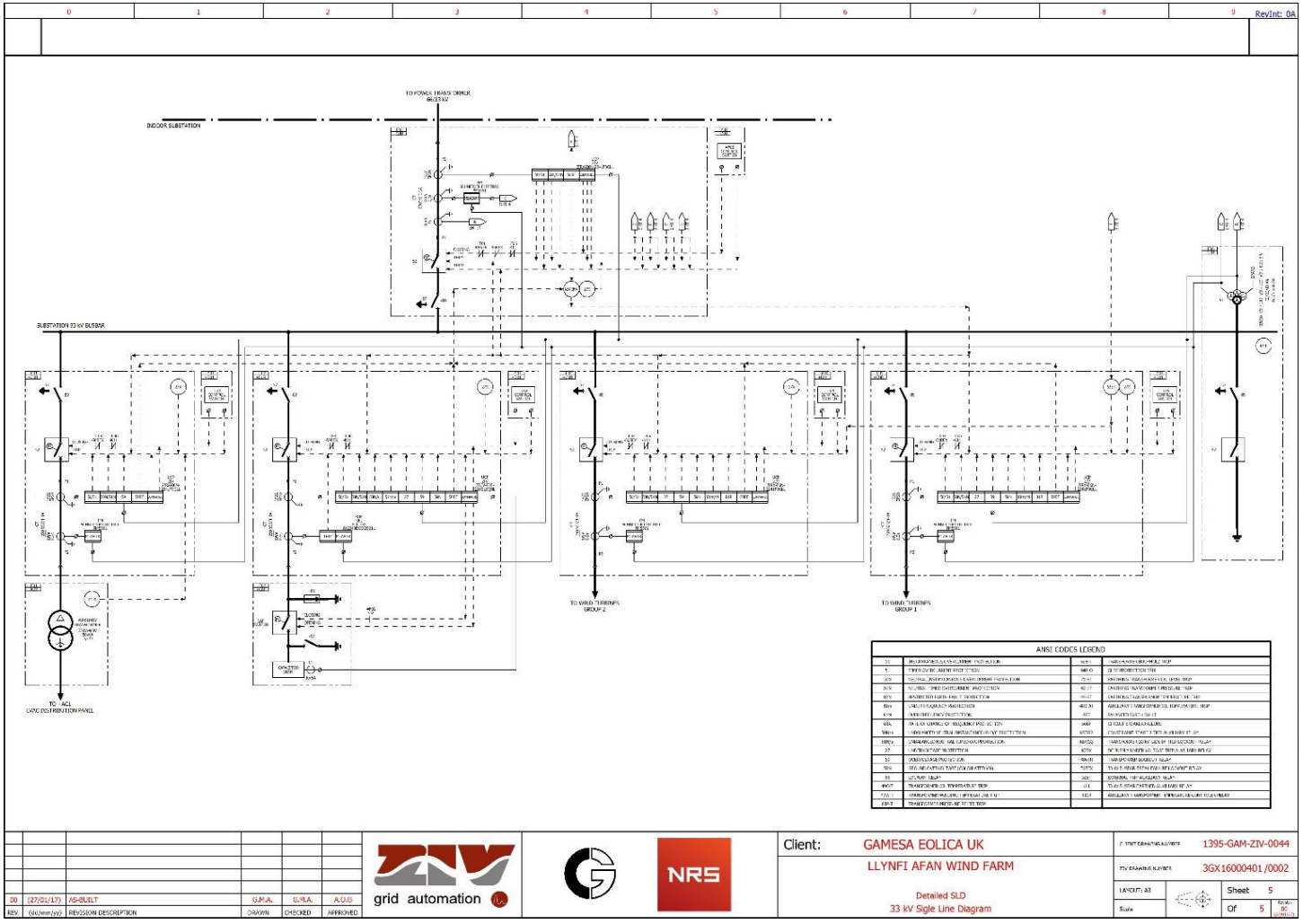

System Architecture

ZIV Automation

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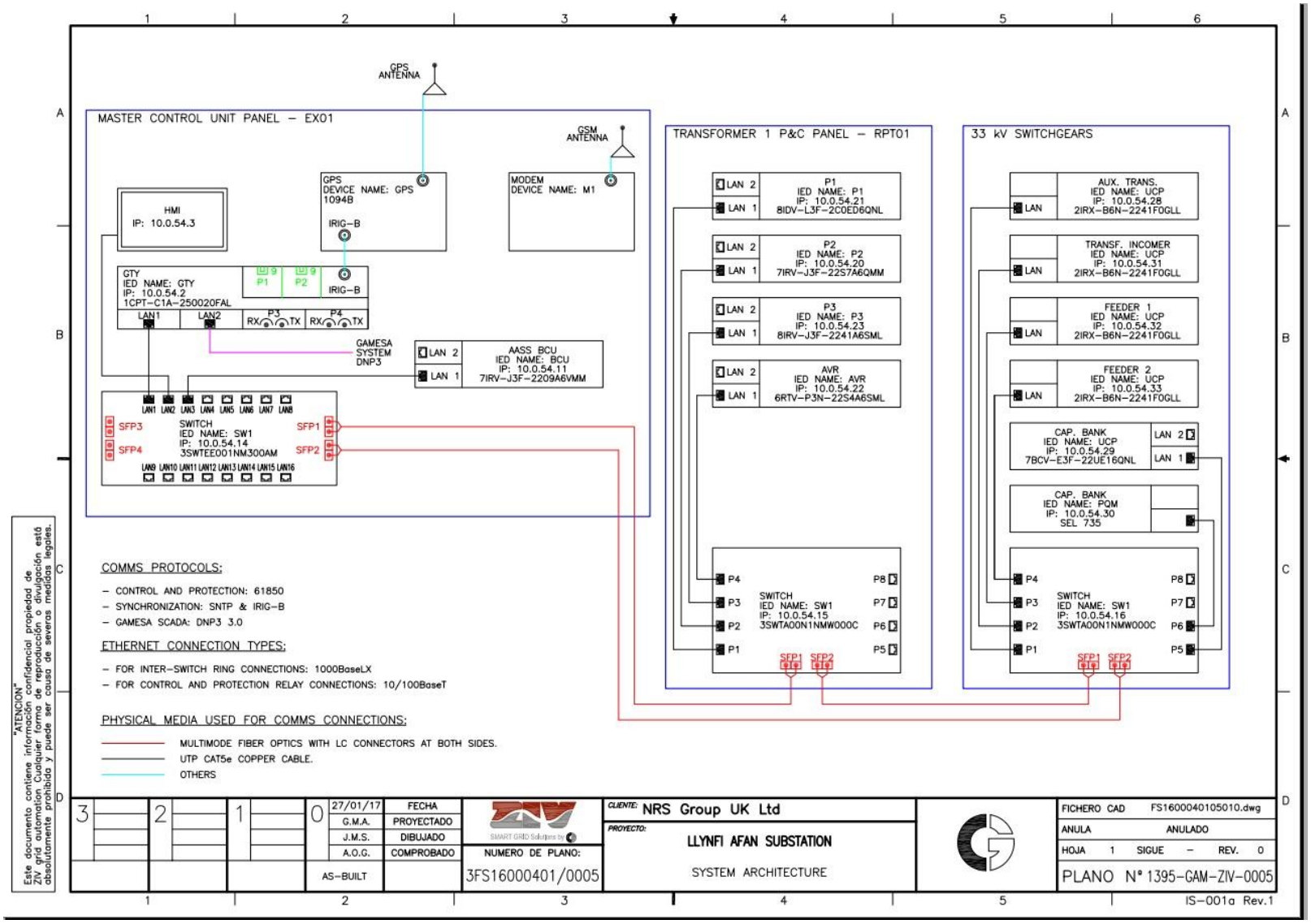

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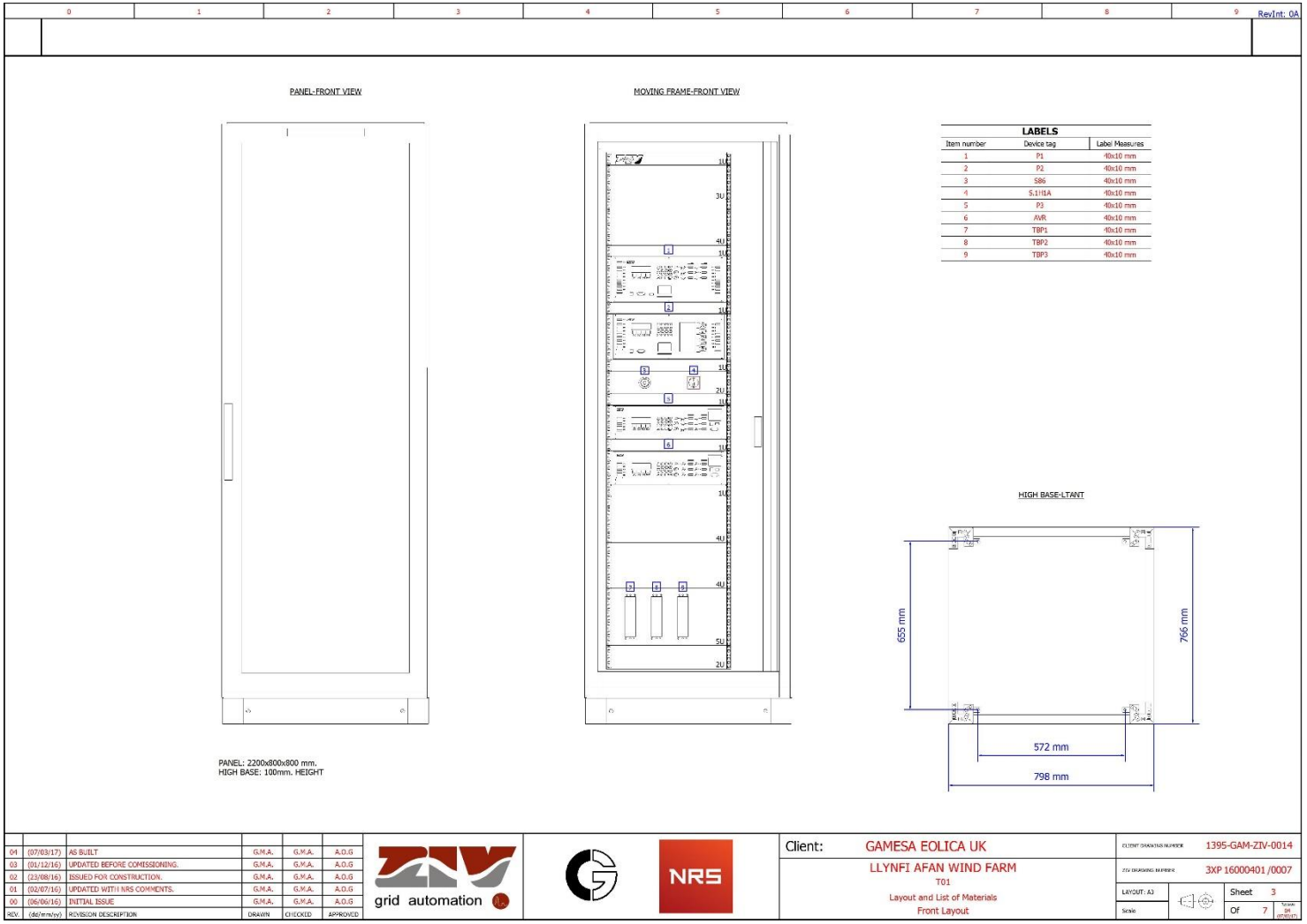
Panel Drawings



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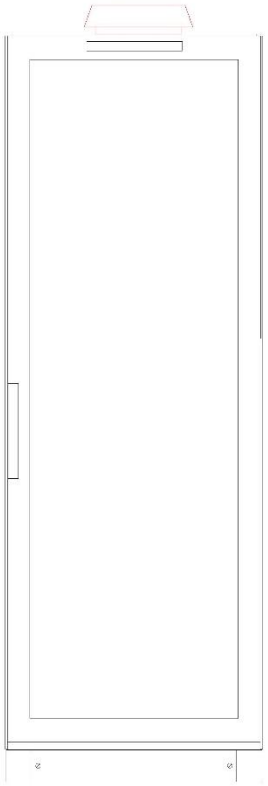
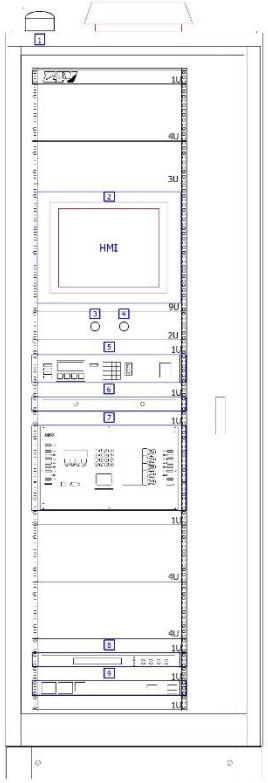
RevInt: 0A

PANEL-FRONT VIEW

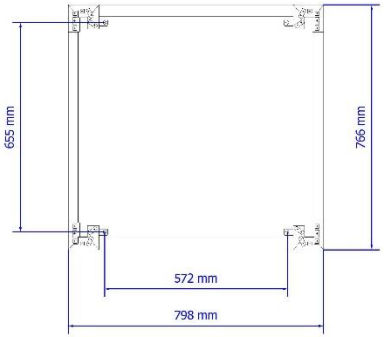


MOVING FRAME-FRONT VIEW



LABELS		
Item number	Device tag	Label Measures
1	H1	40x10 mm
2	HMI	40x10 mm
3	S1H0.G	40x10 mm
4	S1H0.R	40x10 mm
5	GTY	40x10 mm
6	KEYBOARD	40x10 mm
7	BCU	40x10 mm
8	GPS	40x10 mm
9	SW1	40x10 mm

HIGH BASE-LTANT



PANEL: 2200x800x800 mm.
HIGH BASE: 100mm. HEIGHT

REV.	(dd/mm/yy)	REVISION DESCRIPTION	DRAWN	CHECKED	APPROVED
05	(07/03/17)	AS BUILT	G.M.A.	G.M.A.	A.O.G
04	(01/12/16)	UPDATED BEFORE COMISSIONING.	G.M.A.	G.M.A.	A.O.G
03	(13/09/16)	MODEM MODEL UPDATE.	G.M.A.	G.M.A.	A.O.G
02	(23/08/16)	ISSUED FOR CONSTRUCTION.	G.M.A.	G.M.A.	A.O.G
01	(13/07/16)	UPDATED WITH NRS COMMENTS.	G.M.A.	G.M.A.	A.O.G
00	(02/07/16)	INITIAL ISSUE	G.M.A.	G.M.A.	A.O.G

grid automation

Client: GAMESA EOLICA UK

LLYNFI AFAN WIND FARM
Y01
Layout and List of Materials
Front Layout

CLIENT DRAWING NUMBER	1395-GAM-ZIV-0011
ZIV DRAWING NUMBER	3XP 16000401 /0002
LAYOUT: A3	Sheet 3
Scale	Of 6

ZIV Automation

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