

# **WESTERN POWER** **DISTRIBUTION**

*Serving the South West and Wales  
Gwasanaethu'r De Orllewin a Chymru*

- Ivor Rogers
- Primary System Design

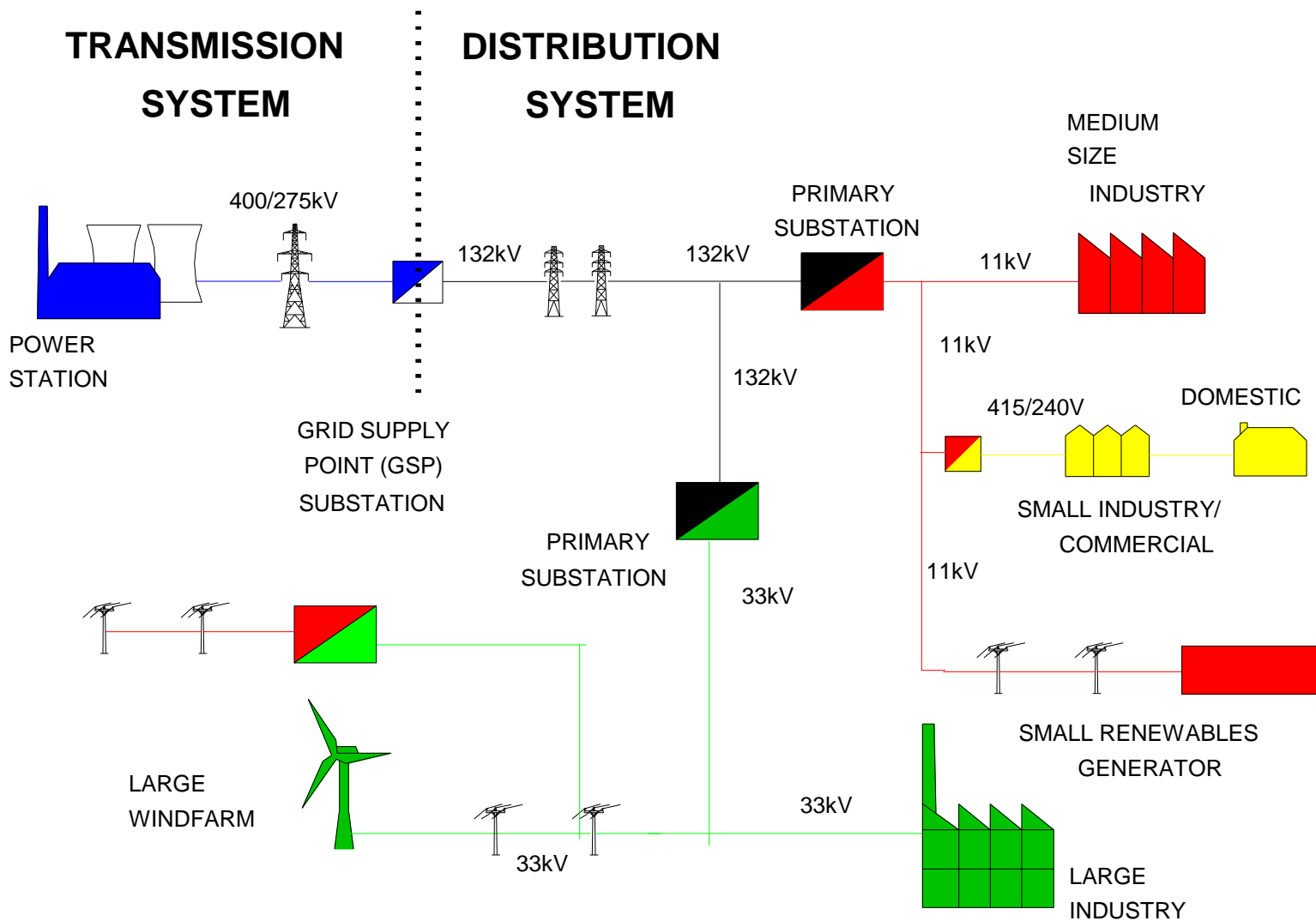
**PEMBROKESHIRE  
MARINE RENEWABLE ENERGY  
INDUSTRY  
SEMINAR**

**Overview of grid capacity in  
Pembrokeshire, limitations, future  
investment proposals and  
opportunities**

# OUTLINE OF PRESENTATION

- Factors affecting Connection of Embedded Generation in Distribution Networks
- Particular factors affecting Connection of Embedded Generation in Pembroke
- Future Investments & Proposals

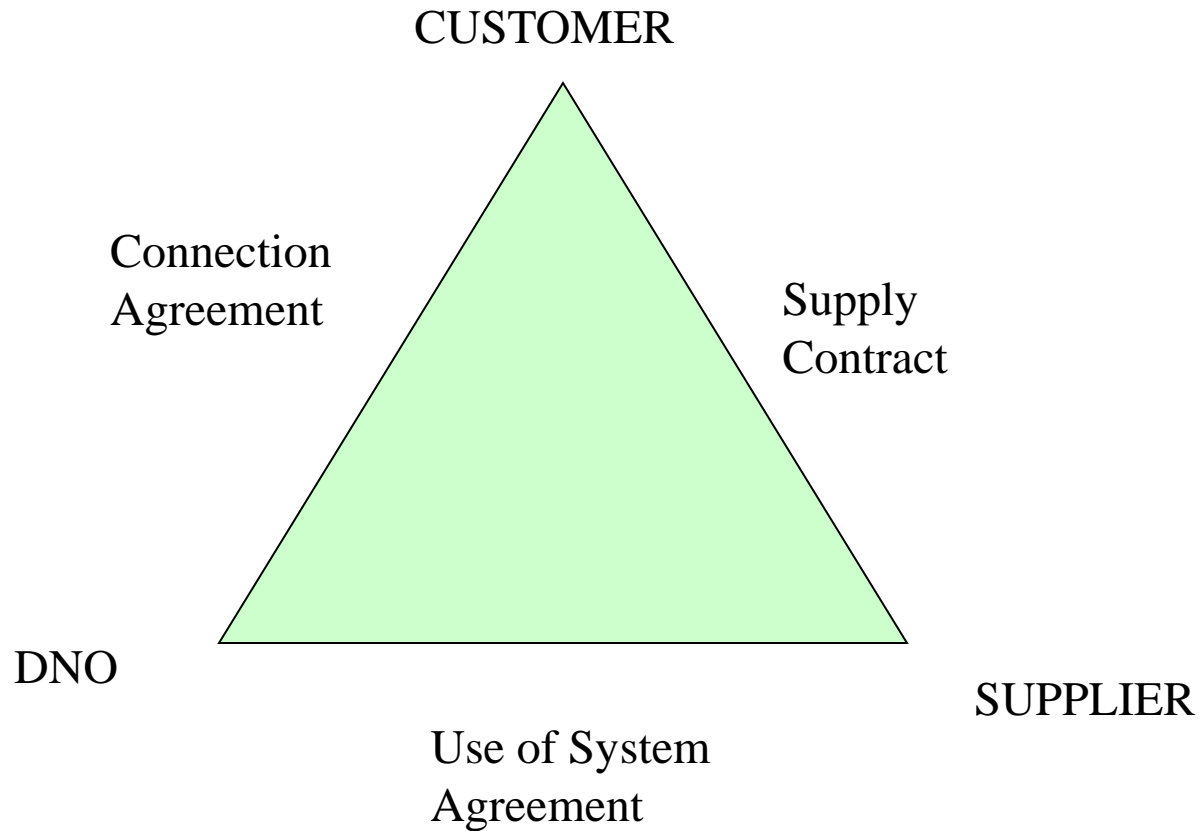
# OUTLINE OF TRANSMISSION AND DISTRIBUTION SYSTEM



# REGULATORY

- Distribution Licence and Distribution Code requirement for connection offer to be made
- Energy Act (1983)
- Electricity Supply Regulations – now superseded by the Electricity Safety, Quality and Continuity Regulations 2002
- The Electricity at Work Regulations (1989)
- Grid Code

# Contractual Framework



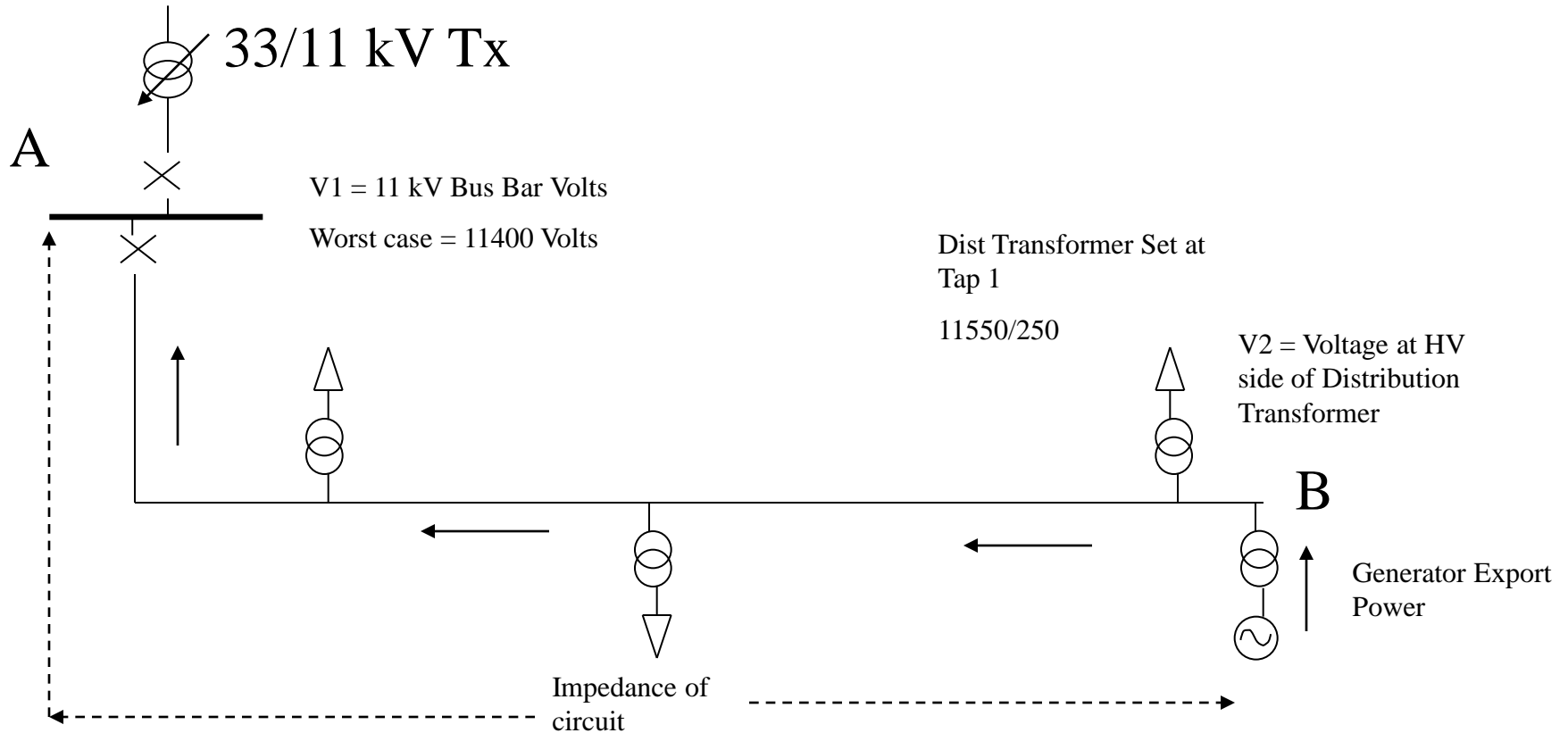
# COMMERCIAL

- Connection Charge
- Sole Use Assets - charged @ 100 %
- Shared Use Assets – charged in line with portion of use
- Connection Agreement – gives written permission to operate parallel generation should indicate synch points and include ownership schedule and diagram

# Factors influencing Connection of Generation

- Thermal Ratings
- Fault Levels
- Voltage Profile
- Voltage Step Change
- Other Technical Issues-  
Protection, Power Quality,  
Earthing

# HV VOLTAGE PROFILE

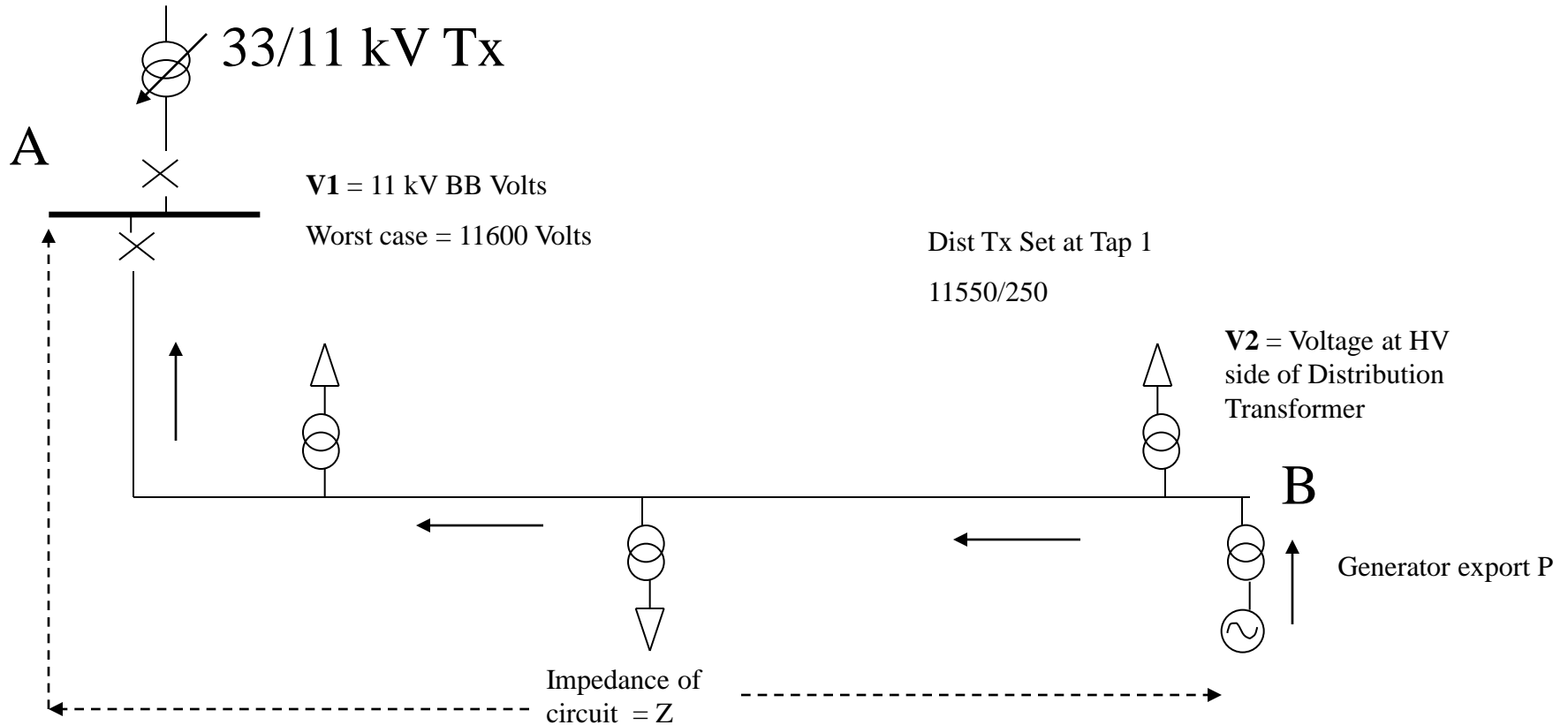


$$V2 = V1 + \text{Voltage Rise A-B}$$

Voltage Rise A- B dependant on Impedance and Power

Larger Impedance and Power = Larger Voltage Rise

# VOLTAGE STEP CHANGE



$$V2 = V1 + \text{Voltage Rise A-B}$$

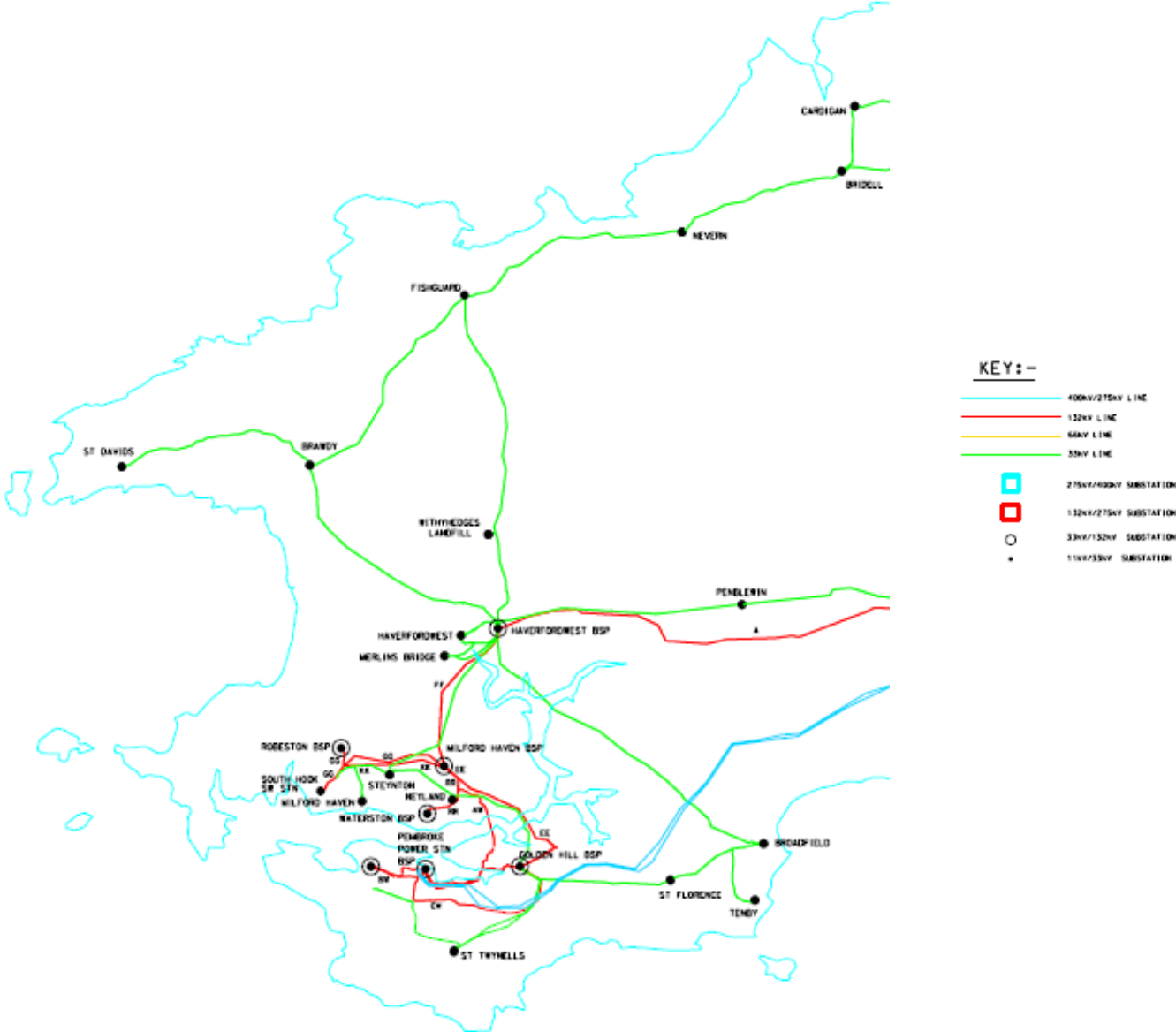
Voltage Rise A- B dependant on Z and P

Larger z and P Larger Voltage Rise ( Max Rise = 60 Volts)

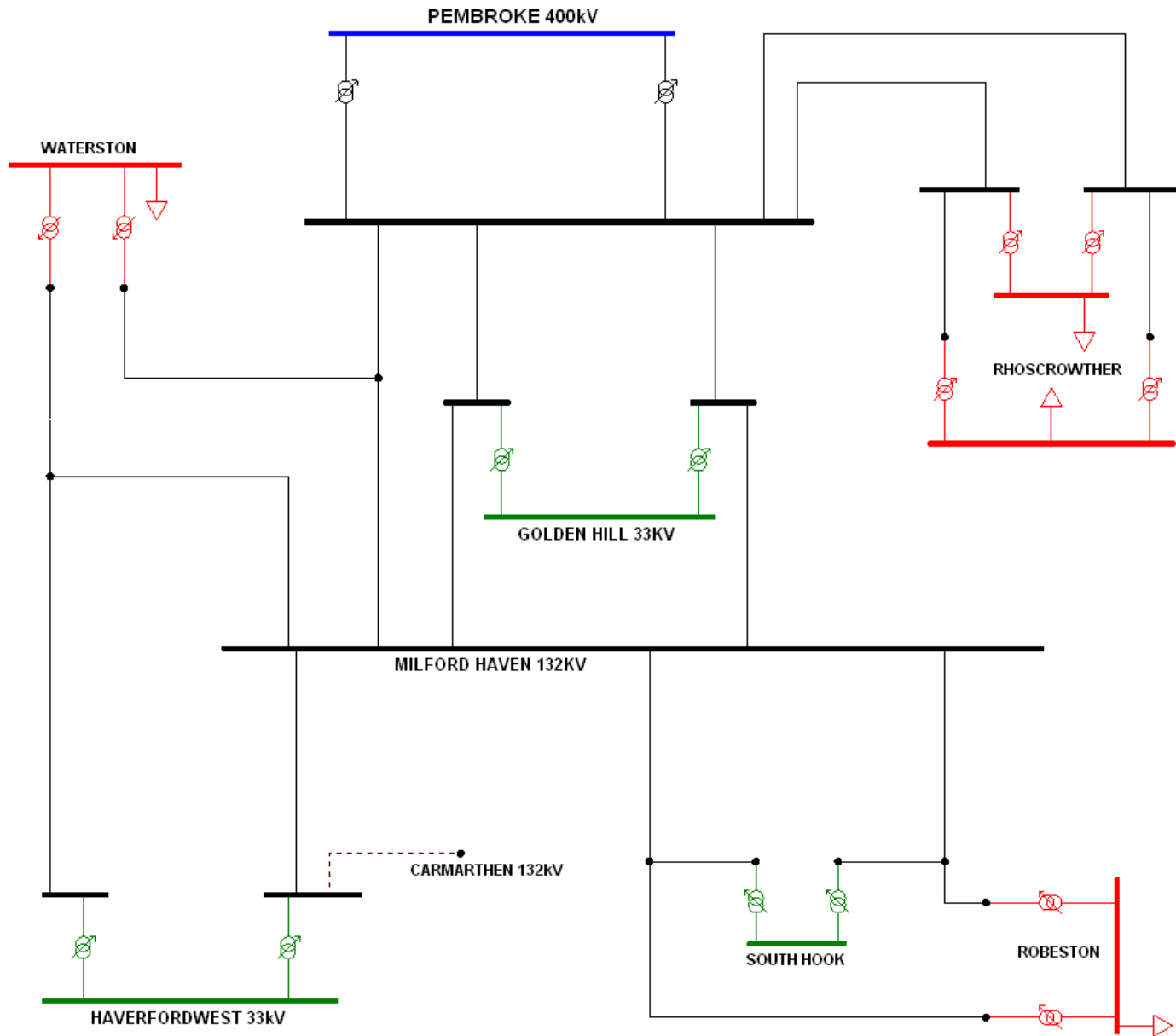
On loss of generation, voltage drops to level it would be without generation- until tap change.

Max step = 6%

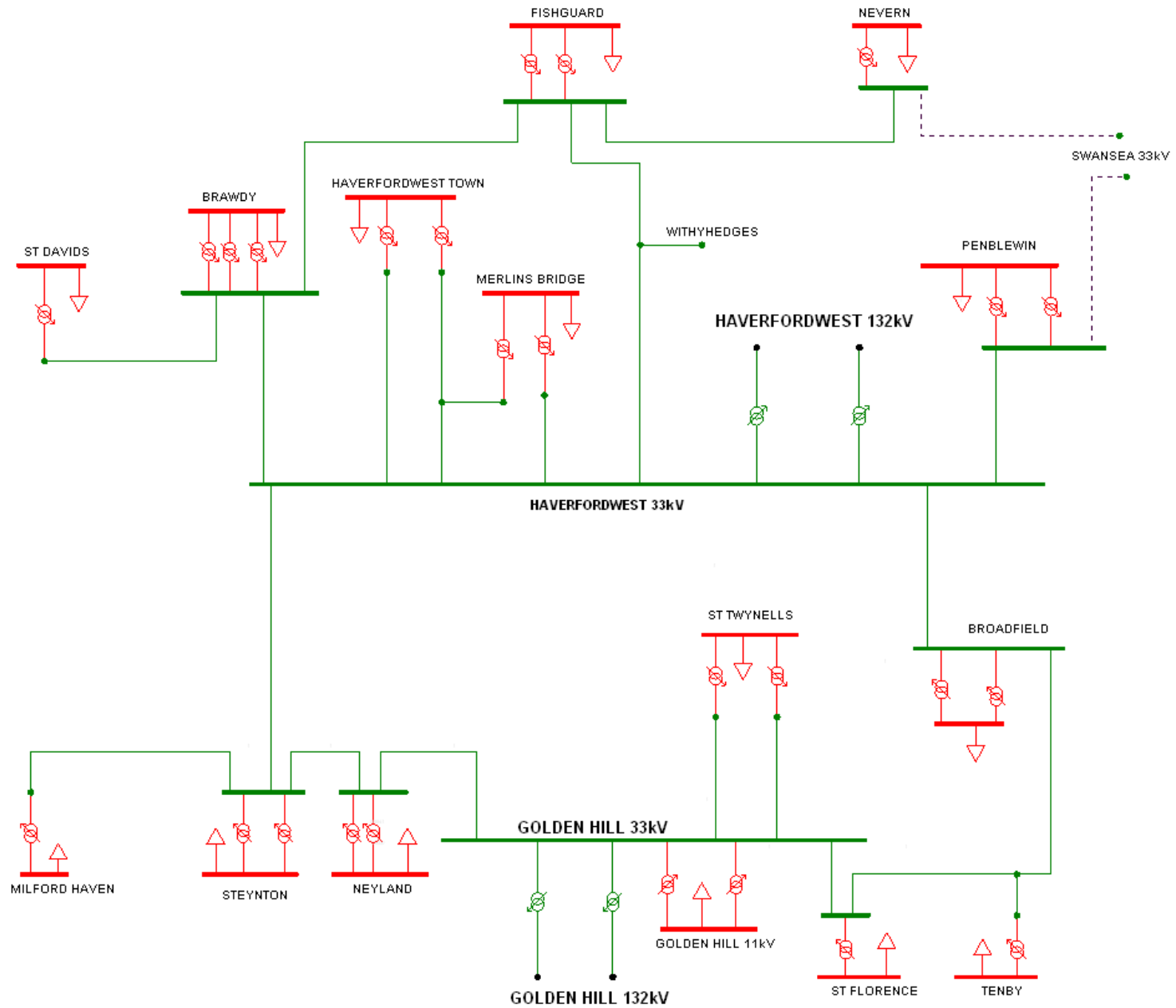
# PEMBROKESHIRE NETWORK



# PEMBROKESHIRE 132kV NETWORK



# PEMBROKESHIRE 33kV NETWORK



# TRANSFORMERS

Transformer	Node 1	Voltage (kV)	Node 2	Voltage (kV)	Minimum Tap (%)	Maximum Tap (%)	Transformer Rating (MVA)	Reverse Power Capability (MVA)
GOLDEN HILL 132/33kV Grid T1	GOLD11	132	GOLD3	33	-20	10	45 OFAF	Not Assessed
GOLDEN HILL 132/33kV Grid T2	GOLD12	132	GOLD3	33	-20	10	45 OFAF	Not Assessed
ROBESTON (ELF) 132/11kV Grid T1	ROBE11	132	ROBE51	11	-20	10	30 OFAF	Not Assessed
ROBESTON (ELF) 132/11kV Grid T2	ROBE12	132	ROBE52	11	-20	10	30 OFAF	Not Assessed
SOUTH HOOK 132/33kV GT1	SHHK11	132	SHHK3	33	-20	10	90 OFAF	90
SOUTH HOOK 132/33kV GT2	SHHK12	132	SHHK3	33	-20	10	90 OFAF	90
BRAWDY 33/11kV T1	BRAW3	33	BRAW5	11	-19	0	7.5 OFAF	Not Assessed
BRAWDY 33/11kV T2	BRAW3	33	BRAW5	11	-19	0	3 ONAN	Not Assessed
BRAWDY 33/11kV T2A	BRAW3	33	BRAW5	11	-19	0	3 ONAN	Not Assessed
BRIDELL 33/11kV T1	BRID3	33	BRID5	11	-19	0	10 OFAF	Not Assessed
BROADFIELD 33/11kV T1	BROF3	33	BROF5	11	-19	0	7.5 OFAF	Not Assessed
BROADFIELD 33/11kV T2	BROF3	33	BROF5	11	-19	0	7.5 OFAF	Not Assessed
CARDIGAN 33/11kV T1	CARG3	33	CARG5	11	-15	5	14 ER	Not Assessed
CARDIGAN 33/11kV T2	CARG3	33	CARG5	11	-15	5	14 ER	Not Assessed
FISHGUARD 33/11kV T1	FISH3	33	FISH5	11	-15	5	14 ER	Not Assessed
FISHGUARD 33/11kV T2	FISH3	33	FISH5	11	-15	5	14 ER	Not Assessed
GOLDEN HILL 33/11 kV T3	GOLD3	33	GOLD5	11	-14	5	24 ER	24
GOLDEN HILL 33/11 kV T4	GOLD3	33	GOLD5	11	-14	5	24 ER	24
MILFORD HAVEN 33/11kV T1	MIFH3	33	MILP5	11	-15	5	14 ER	Not Assessed
NEVERN 33/11kV T1	NEVE31	33	NEVE5	11	-19	0	3 ONAN	Not Assessed
NEVERN 33/11kV T2	NEVE32	33	NEVE5	11	-19	0	3 ONAN	Not Assessed
NEYLAND 33/11kV T1	NEYL3	33	NEYL5	11	-19	0	3 ONAN	Not Assessed
NEYLAND 33/11kV T2	NEYL3	33	NEYL5	11	-14	5	5 ONAN	6.25
ST DAVIDS 33/11kV T1	STDA3	33	STDA5	11	-19	0	3 ONAN	Not Assessed
ST FLORENCE 33/11kV T1	STFL3	33	STFL5	11	-19	0	5 ONAN	Not Assessed
ST TWYNELLS 33/11kV T1	STTW31	33	STTW5	11	-19	0	3 ONAN	Not Assessed
ST TWYNELLS 33/11kV T2	STTW32	33	STTW5	11	-19	0	3 ONAN	Not Assessed
STEYNTON 33/11kV T1	STEY3	33	STEY5	11	-19	0	10 OFAF	Not Assessed
STEYNTON 33/11kV T2	STEY3	33	STEY5	11	-19	0	10 OFAF	Not Assessed
TENBY 33/11kV T1	TENB3	33	TENB5	11	-15	5	14 ER	Not Assessed

All transformer ratings are the nominal ( i.e. continuous) rating. Where two ratings are shown this represents the nominal rating without/with forced cooling with the exception of 'emergency rated' transformers which are shown as the nominal rating without forced cooling/ the 'emergency rating' ( as per EA Technical Specification 35-2).

Abbreviations used are:-

ONAN Natural Air Natural  
 ONAF Natural Air Forced  
 OFAN Forced Air Natural  
 OFAF Forced Air Forced  
 ER Emergency Rated (CER) or Integrated System Transformer (IST)

Values stated for reverse power capabilities of transformers are only indicative, as the reverse power capability is dependant upon power factor of the exported power.

# Circuit Ratings

Node 1	Node 2	Voltage (kV)	Circuit Code	Cold Rating (MVA)	Normal Rating (MVA)	Hot Rating (MVA)	Circuit Length (km)
PEMB1B	GOLD12	132	L1	150	144	134	7.16
TROS11	W101	132	L1	192	151	119	2.28
TEXA12	PEMB1A	132	L2	117	113	111	3.811
TEXA13	TEXA11	132	L1	103	100	98	0.045
TEXA14	TEXA12	132	L1	103	100	98	0.085
GOLD11	PEMB1A	132	L1	135	112	91	12.57
HAVE11	MHAV1A	132	L1	125	107	90	9.46
HAVE12	MIFH1	132	L1	125	107	90	9.6
MIFH1	GOLD11	132	L1	125	107	90	10.538
MIFH1	GOLD12	132	L1	125	107	90	10.426
ROBE11	ROBT11	132	L1	125	107	90	1.02
ROBE12	ROBT12	132	L2	125	107	90	1.02
SHHK11	ROBT11	132	L1	125	107	90	2.011
SHHK12	ROBT12	132	L1	125	107	90	2.011
WATE11	PEMT1	132	L1	125	107	90	2.54
WATE12	GLFM1	132	L1	125	107	90	2.54
TEXA11	PEMB1B	132	L1	87	87	87	3.582
NEVE31	NEVE32	33	L0	23	23	23	0.002
MERB32	MERB3T	33	L1	23	23	22	2.038
TRET32	ENER3T	33	L1	33	27	22	5.663
TREV31	CARM3A	33	L1	33	27	22	3.316
TREV32	CARM3A	33	L1	27	27	22	3.716
SHIP3	BRH13	33	L1	22	21	21	3.944
MERB3T	HAVE3	33	L1	26	24	20	1.884
GOLD3	NEYL3	33	L1	23	23	19	8.591
MERB31	HAVE3	33	L1	23	23	19	4.107
FISH3	BRAW3	33	L1	23	19	16	14.018
FISH3	WTHY3T	33	L1	23	19	16	14.422
NEVE31	BRID3T	33	L1	23	19	16	10.139
NEVE32	FISH3	33	L1	23	19	16	13.938
STDA3	BRAW3	33	L1	23	19	16	12.487
TENB3	TENB3T	33	L1	23	19	16	4.104
WTHY3	WTHY3T	33	L1	23	19	16	0.46
WTHY3T	HAVE3	33	L1	23	19	16	5.781
BRAW3	HAVE3	33	L1	17	17	15	16.026
BROF3	HAVE3	33	L1	22	18	15	20.866
PEBL3	HAVE3	33	L1	17	17	15	14.565
PEBL3	PEBL3T	33	L1	17	17	15	9.428
STEY3	HAVE3	33	L1	17	17	15	11.257
STFL3	GOLD3	33	L1	22	18	15	9.444
TENB3T	STFL3	33	L1	22	18	15	4.254
HAVP31	HAVE3	33	L1	13	12	12	2.818
HAVP32	MERB3T	33	L1	13	12	12	1.268
MIFH3	STEY3	33	L1	14	12	10	4.337
STTW31	GOLD3	33	L1	14	12	10	8.472
STTW32	GOLD3	33	L2	14	12	10	8.442

# Fault levels

Substation	Voltage Level (kV)	Existing System Fault Level (see notes 2&3)					Rating (see notes 3&4&5)				% of Rating	
			3ph Peak Make (kA)	1ph Peak Make (kA)	3ph rms Break (kA)	1ph rms Break (kA)	3ph Make (kA)	1ph Make (kA)	3ph Break (kA)	1ph Break (kA)	3ph Make (kA)	3ph Break (kA)
RHOSCROWTHER 11kV	11	55.56			18.84			25			89%	75%
ROBESTON 11kV 2	11	52.41	17.97		18.61	6.47		26.2	0.64		80%	71%
WATERSTON 11kV 2	11	51.97			19.11			26.2			79%	73%
ROBESTON 11kV 1	11	48.13	17.64		17.13	6.35		26.2	0.66		73%	65%
PEMBROKE 132kV 1	132	27.79	34.99	9.5	12.91	38.25	46	15.3	18.4		73%	62%
PEMBROKE 132kV 2	132	27.79	34.99	9.5	12.91	38.25	46	15.3	18.4		73%	62%
PEMBROKE 132kV 3	132	27.79	34.99	9.5	12.91	38.25	46	15.3	18.4		73%	62%
GOLDEN HILL 132kV 2	132	24.93	29.47	8.87	11.41	38.25	38.25	15.3	15.3		65%	58%
WATERSTON 11kV 1	11	61.44		21.07		100		40			61%	53%
MILFORD HAVEN 132kV	132	22.41	26.97	8.16	10.67	38.25	38.25	15.3	15.3		59%	53%
MERLINS BRIDGE 11kV	11	19.04		7.48		32.75		13.1			58%	57%
STEYNTON 33kV	33	12.12		5.34		21.75		8.7			56%	61%
GOLDEN HILL 132kV 1	132	18.5	20.77	7.23	8.85	38.25	38.25	15.3	15.3		48%	47%
HAVERFORDWEST 33kV	33	29.26		11.2		62.5		25			47%	45%
GOLDEN HILL 33kV	33	28.83		11.08		62.5		25			46%	44%
SOUTH HOOK 33 kV	33	26.38		9.94		62.5		25			42%	40%
HAVERFORD WEST P/STN 11kV	11	19.36		7.67		50		20			39%	38%
BROADFIELD 33kV	33	8.34		3.88		21.75		8.7			38%	45%
GOLDEN HILL 11kV	11	21.54		7.8		62.5		25			34%	31%
RHOSCROWTHER 132kV 2	132	25.32	30.25	9.03	12.05	78.75	78.75	31.5	31.5		32%	29%
RHOSCROWTHER 132kV 4	132	25.25	30.1	9.02	12.02	78.75	78.75	31.5	31.5		32%	29%
ST FLORENCE 33kV	33	9.89		4.55		32.75		13.1			30%	35%
NEYLAND 33kV	33	13.12		5.65		43.75		17.5			30%	32%
RHOSCROWTHER 132kV 1	132	22.07	23.52	8.12	9.37	78.75	78.75	31.5	31.5		28%	26%
RHOSCROWTHER 132kV 3	132	22.03	23.47	8.11	9.36	78.75	78.75	31.5	31.5		28%	26%
FISHGUARD 33kV	33	6.06		2.83		21.75		8.7			28%	33%
MILFORD HAVEN 11kV	11	8.24		3.75		32.75		13.1			25%	29%
NEYLAND 11kV	11	11.93		4.88		50		20			24%	24%
BRAWDY 11kV	11	11.81		4.85		50		20			24%	24%
FISHGUARD 11kV	11	11.79		4.8		50		20			24%	24%
PENBLEWIN 33kV	33	5.08		2.38		21.75		8.7			23%	27%
TENBY 11kV	11	7.53		3.38		32.75		13.1			23%	26%
HAVERFORDWEST 132kV 2	132	14.11	15.21	5.86	6.73	62.5	78.75	25	31.5		23%	23%
ST FLORENCE 11kV	11	7.01		2.94		31.25		12.5			22%	24%
BROADFIELD 11kV	11	12.16		5.4		62.5		25			19%	22%
PENBLEWIN 11kV	11	11.5		4.73		62.5		25			18%	19%
WITHYHEDGES 33kV	33	10.72		4.88		62.5		25			17%	20%
NEVERN 33kV 1	33	3.63		1.81		21.75		8.7			17%	21%
ST TWYNELLS 33kV 1	33	9.82		4.26		62.5		25			16%	17%
ST TWYNELLS 11kV	11	9.35		4.11		62.5		25			15%	16%
SOUTH HOOK 132kV 2	132	14.95	16.21	6.11	6.95	100	100	40	40		15%	15%
SOUTH HOOK 132kV 1	132	14.63	15.95	6.01	6.85	100	100	40	40		15%	15%
HAVERFORDWEST 132kV 1	132	14.16	15.33	5.87	6.75	100	100	40	40		14%	15%
NEVERN 33kV 2	33	2.95		1.46		21.75		8.7			14%	17%
NEVERN 11kV	11	4.34		1.77		32.75		13.1			13%	14%
ST DAVIDS 11kV	11	3.51		1.64		31.25		12.5			11%	13%
ST TWYNELLS 33kV 2	33	6.58		3.44		62.5		25			11%	14%
BRAWDY 33kV	33	6.42		3		62.5		25			10%	12%

# WPD Network Schemes Over Next 5 years in Pembrokeshire

- Further 11kV network refurbishment and automation
- Major refurbishment Milford Haven 132kV substation
- Reinforce Haverfordwest to Brawdy 33kV circuit
- Reinforce Haverfordwest to Fishguard 33kV circuit
- Reinforce Haverfordwest to St Florence 33kV circuit
- Reinforce Haverfordwest to Broadfield 33kV circuit
- Installation of Static Voltage Compensation at Brawdy

# Useful Documents

- G59/1 – Recommendations for the connection of embedded generating plant to the public electricity supplier's distribution system
- ETR 113 – Notes of guidance for the protection of embedded generating plant up to 5 MW for operation in parallel with the public electricity supplier's distribution system
- G75– Recommendations for the connection of embedded generating plant to the public electricity supplier's distribution systems above 20 kV or with outputs over 5 MW