Risk Assessment of Loss of Mains Protection – Phase II

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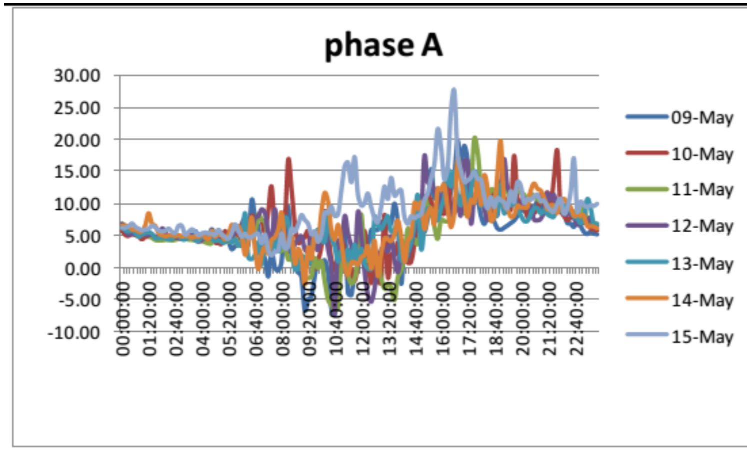
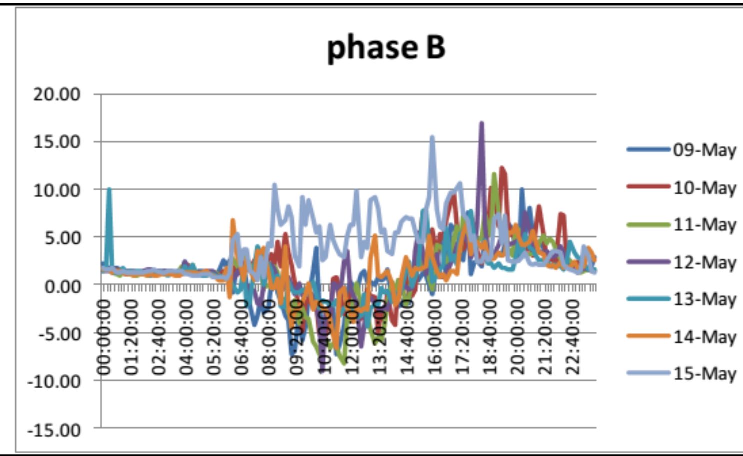
Update summary

- Contract and costing approved – final negotiations with ENA taking place ✓
- National Fault and Interruption Reporting Scheme
  - Richard Le Gros provided G43 and offered help with data acquisition. ✓
  - Perhaps, using updated QoS reports would be more effective.
- WS7 Work – Contact provided by Mike – Gillian Williamson
  - No response so far but will follow up ✓
- No further monitoring data/information received from DNOs ✗
- Samples of PV generation data perhaps can be obtained at Strathclyde from the exiting PV rig. ✓
- 10min 3-phase LV data is available from earlier work with SP ✓

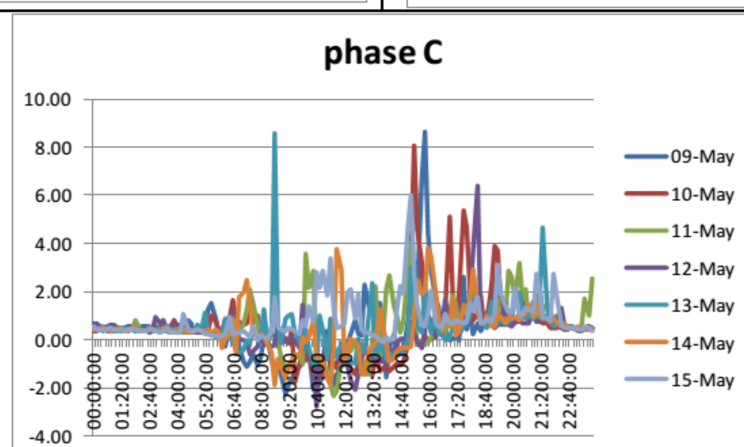
Available LV monitoring data

- Load Monitoring Data – SP
  - 10min resolution over 2 weeks



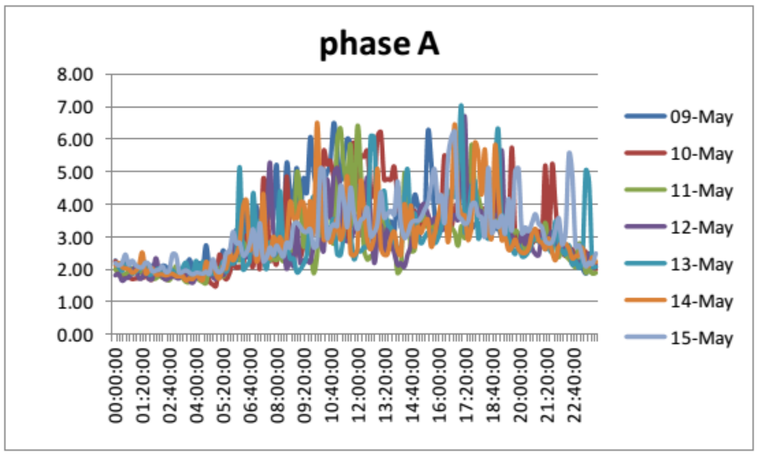


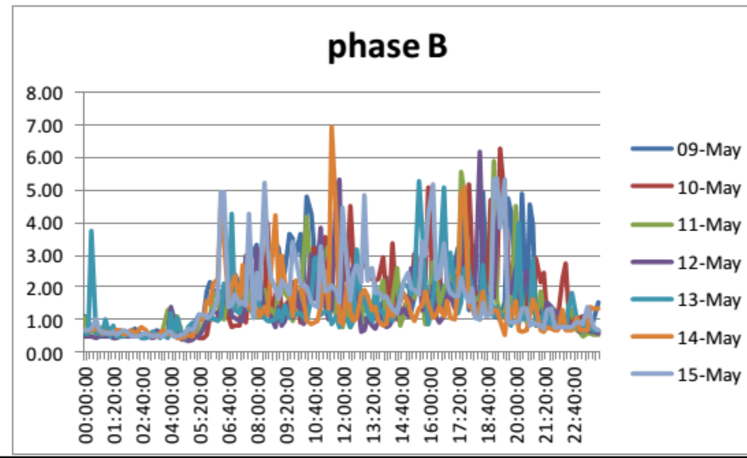
P [kW]



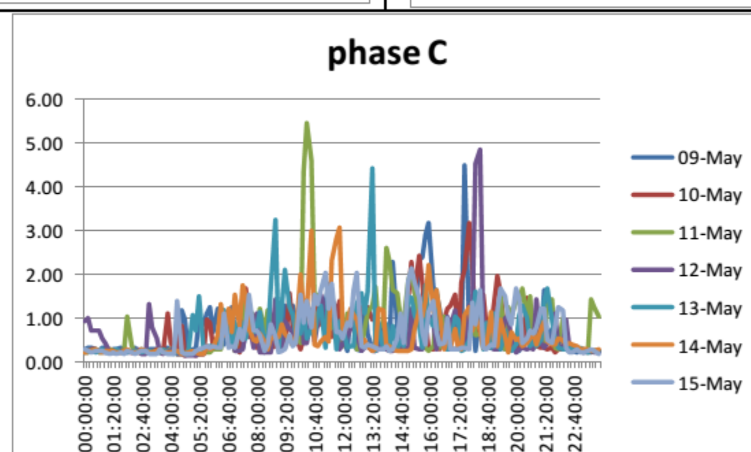
Available LV monitoring data

- Load Monitoring Data – SP
  - 10min resolution over 2 weeks





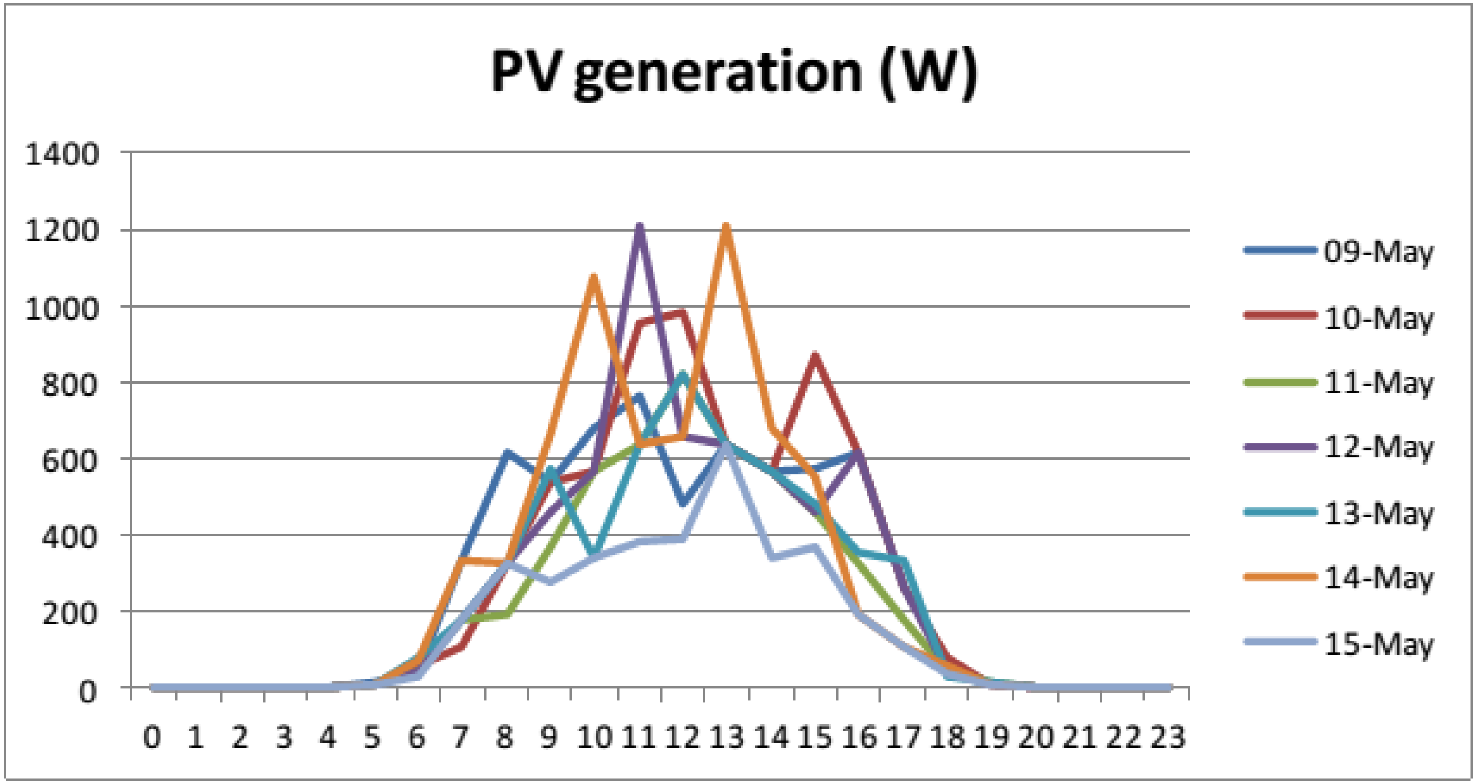
Q [kVAr]



PV generation profile

- Could be characterised using a normalised solar index from NPL

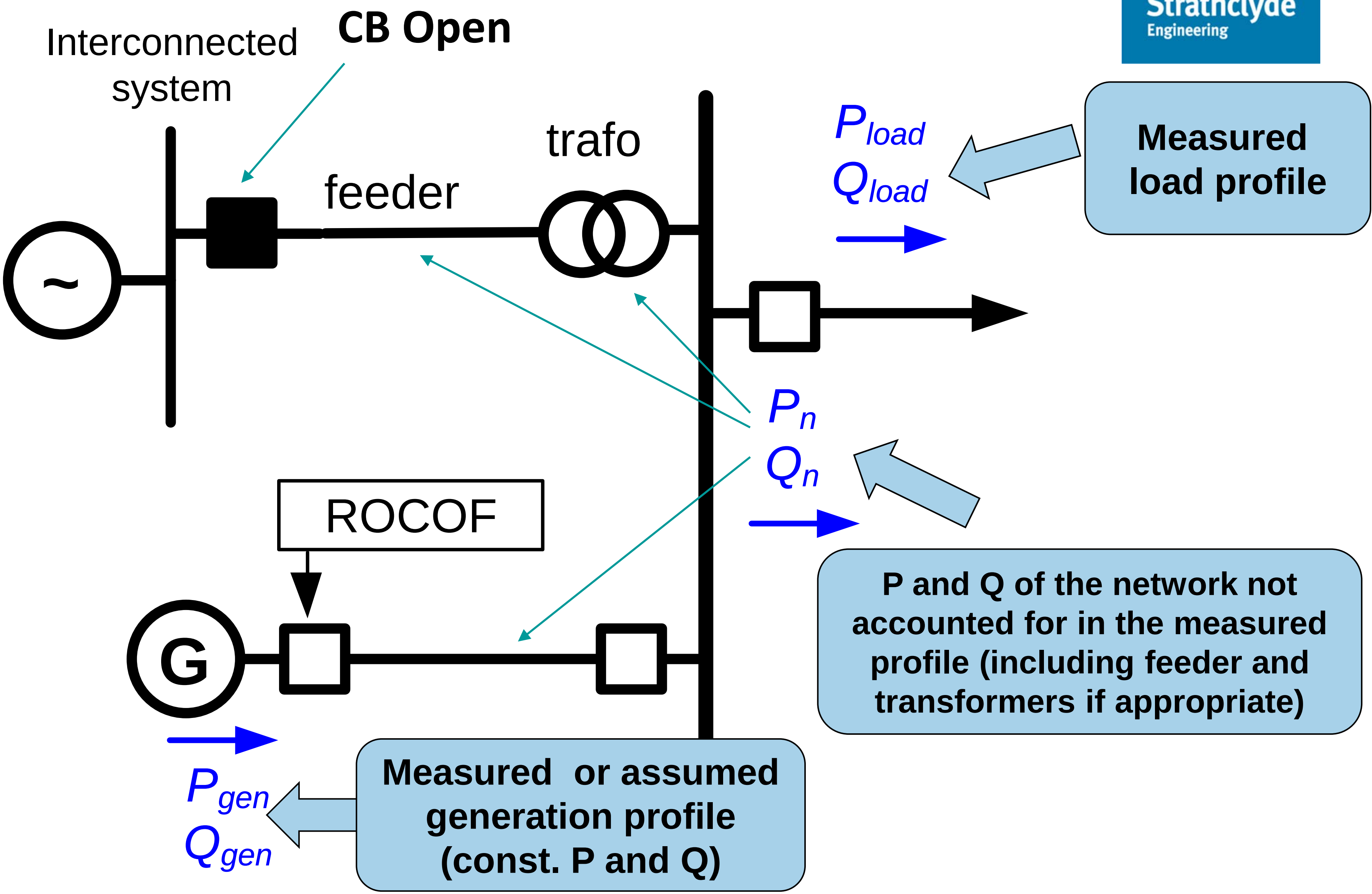
P [W]



Data still needed

- Monitoring data
  - 1s resolution data from example 11kV and LV feeders
  - Any monitoring data of typical DG
- DG capacity statistics from other DNOs (other than ENW).

Network model for the probability tree



Identification of possible island formation scenarios

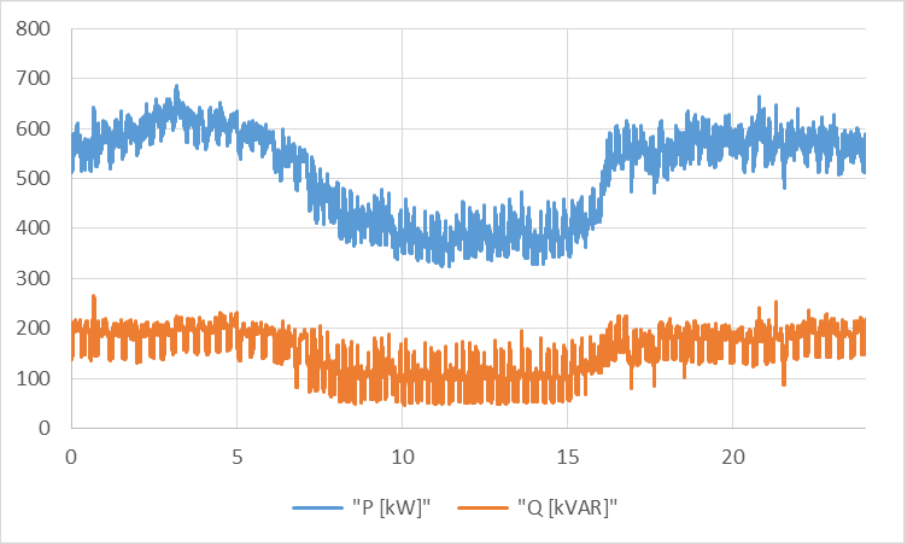
- Loss of 33kV feeder
- Loss of 11kV or 6.6kV feeder or transformer
- Loss of LV circuit

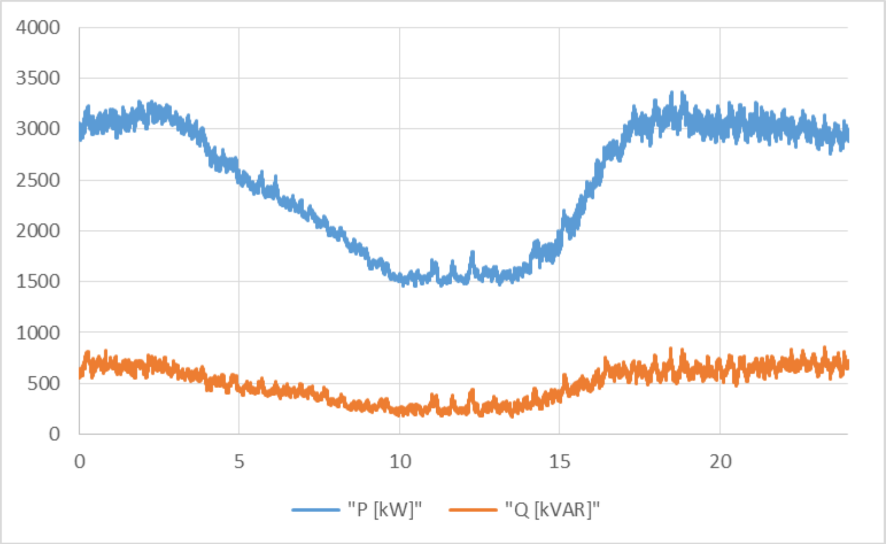
Available information to date

Available monitoring data

- Load Monitoring Data – ENW
  - 1min resolution for distribution substations
  - 1s available for primary substations

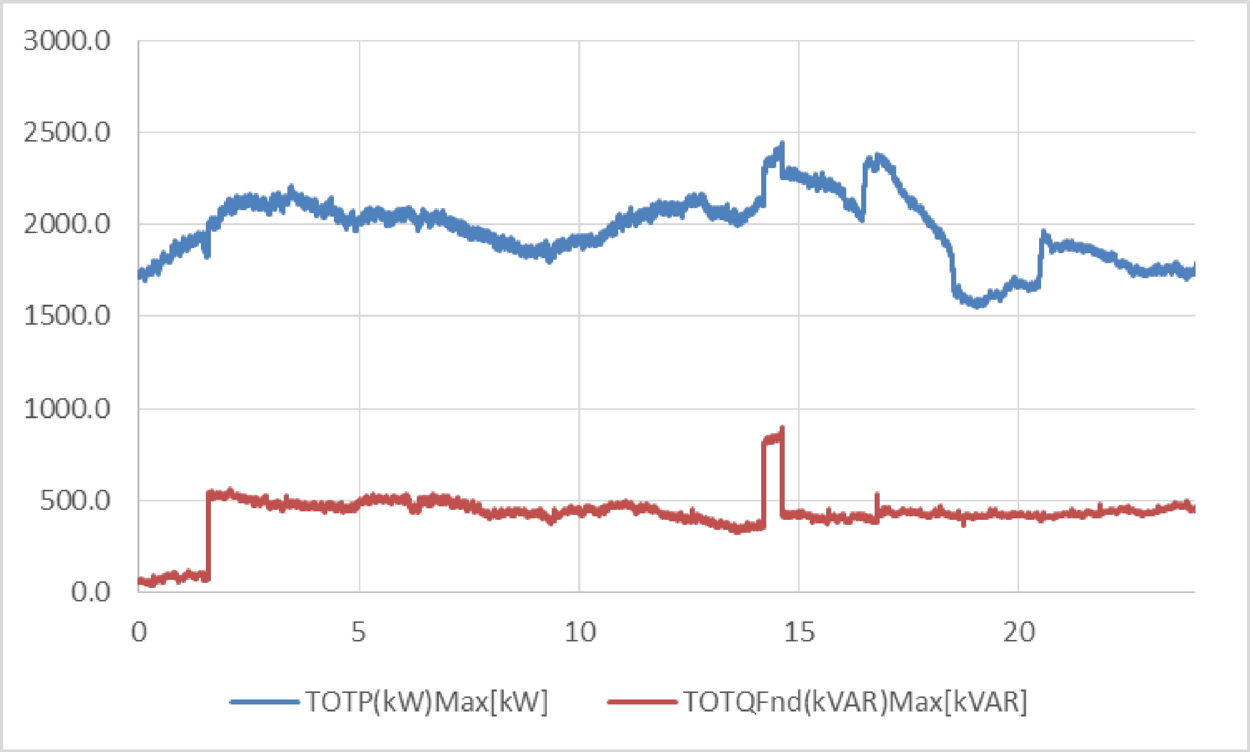
- Two 1s records (over 24h) recorded in 2008





Available monitoring data

- Load Monitoring Data captured in Phase I
  - 11kV Chelford - 1s resolution



DG Capacity Characterisation

- ENW

LV connected above 100kW			Export Capablity	MW
Technology	No Of Sites	MW connected	Yes	1.3
Hydro	6	0.758	No	11.2
Landfill gas, sewage gas, biogas (not CHP)	2	0.473	Not recorded	11.1
Micro CHP (domestic)	1	0.127		
Mini CHP (<1MW)	53	10.457		
Onshore wind	8	1.185		
Other generation	18	6.205		
Photovoltaic	26	4.38		
Grand Total	114	23.585		

HV Connected Up To 5MW			Export Capablity	MW
Technology	No Of Sites	MW connected	Yes	243.2
Biomass & energy crops (not CHP)	3	5.1	No	73.1
Hydro	17	5.046	Not recorded	42.8
Landfill gas, sewage gas, biogas (not CHP)	79	116.201		
Medium CHP (> = 5MW, < 50MW)	1	3.4		
Mini CHP (<1MW)	64	19.863		
Onshore wind	42	56.325		
Other generation	65	80.149		
Photovoltaic	35	6.904		
Small CHP (> = 1MW, < 5MW)	30	64.221		
Waste incineration (not CHP)	1	2		
Grand Total	337	359.209		

All Connected LV Generation		
Technology	No Of Sites	MW connected
Hydro	27	1.446
Landfill gas, sewage gas, biogas (not CHP)	3	0.503
Micro CHP (domestic)	122	0.311
Mini CHP (<1MW)	130	14.51
Onshore wind	343	6.47
Other generation	29	6.137
Photovoltaic	22324	80.59
Small CHP (> = 1MW, < 5MW)	1	1.865
Grand Total	22979	111.832

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DG Capacity Characterisation

- LTDS

LTDS Summary (<5MW)
23 July 2014

	MW Capacity									Number of Sites								
	ENW	Manweb	NPG	SEPD	SHEPD	SPD	UKPN	WPD	**Grand Total**	ENW	Manweb	NPG	SEPD	SHEPD	SPD	UKPN	WPD	**Grand Total**
"Accepted"																		
Biomass								10	**10**								4	**4**
CHP				1				5	**6**				1				2	**3**
Hydro								3	**3**								1	**1**
Onshore Wind						7		21	**28**						2		7	**9**
Other			4	1				7	**12**			1	1				3	**5**
Solar								114	**114**								32	**32**
Waste						5			**5**						1			**1**
Total "Accepted"			4	2		12		160	**177**			1	2		3		49	**55**
"Connected"																		
Battery					2				**2**					1				**1**
Bio Fuel							4		**4**							1		**1**
Biomass	5	3	19		2		4	11	**44**	1	2	7		2		1	6	**19**
CHP	68	21	104	28		4	91	32	**349**	32	8	38	15		1	45	13	**152**
Diesel				4			92	6	**103**				3			43	2	**48**
Gas		5		34			12		**52**		1		16			6		**23**
Gas CHP					9				**9**					4				**4**
Hydro		4			93	3		10	**111**		1			42	2		3	**48**
Landfill Gas, Sewage Gas, Biogas	104	45		74	15		112	161	**512**	53	21		36	6		51	70	**237**
Offshore Onshore Wind			4						**4**			1						**1**
Onshore Wind	56	17	34	2	136	10	22	48	**326**	19	7	12	1	46	4	7	18	**114**
Other	57		94				1	116	**268**	27		44				1	51	**123**
Solar		1	3	12			39	143	**199**		1	1	3			16	41	**62**
Tidal					4				**4**					1				**1**
Traction		6							**6**		2							**2**
Waste	2	4	9			71		33	**120**	1	1	4			26		14	**46**
Total "Connected"	292	107	267	158	262	89	378	560	**2112**	133	44	107	75	102	33	171	218	**883**
Grand Total	**292**	**107**	**271**	**160**	**262**	**100**	**378**	**719**	**2290**	**133**	**44**	**108**	**77**	**102**	**36**	**171**	**267**	**938**

Network Characterisation

- Smart Grids Forum – Work Stream 3 – "Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Networks"
  - Future trends of low carbon technology uptake is included - useful in calculating the risks in the future.
  - Representative models of typical distribution feeders are developed
- Smart Grids Forum – Work Stream 7

Network Characterisation

- ENW – descriptive distribution network characteristic

Characteristic HV feeders:

Emanating from a primary substation (both 11kV and 6.6kV) – one of a number of feeders (typically between 4 and 20 per primary substation) supporting gross demand (ie without ANY generation) of between 2MW and 30MW on each feeder.

Some feeders will be wholly underground; some nearly all overhead; many will be a composite.

11kV feeder loadings (gross) can be up to 7MW; 6.6kV feeder loadings (gross) up to 4MW

Feeders will all have simple IDMT source protection operating a circuit breaker. There is some unit protection at 11kV, but it is only applied to a relatively small percentage of 11kV networks. A few, but rapidly rising, number of feeders will have autoreclose on the circuit breaker, or be part of an automation scheme. Dead times varying between 3s and 180s. Many feeders will have further automatic switchgear with reclose capability at various points on the feeder. Typically up to 3 per feeder. Feeders likely to run in closed rings in future – ie so up to six switch automatic switch positions on a pair of feeders run together as closed ring or standing by to each other through a single open point.

Characteristic Network Substations

Range from 25kVA pole transformer for a single customer; multiple customers on a single fuse from a pole transformer, through to 1000kVA transformer feeding up to a dozen individual LV feeders.

Pole mounted transformers protected as part of the HV line protection. Ground mounted transformers protected by a non-reclosing device.

LV circuits protected predominantly by high rupturing capacity fuses – although some circuit breakers are deployed on a per phase per way basis as part of very recent automation developments.,

Characteristics of LV Circuits

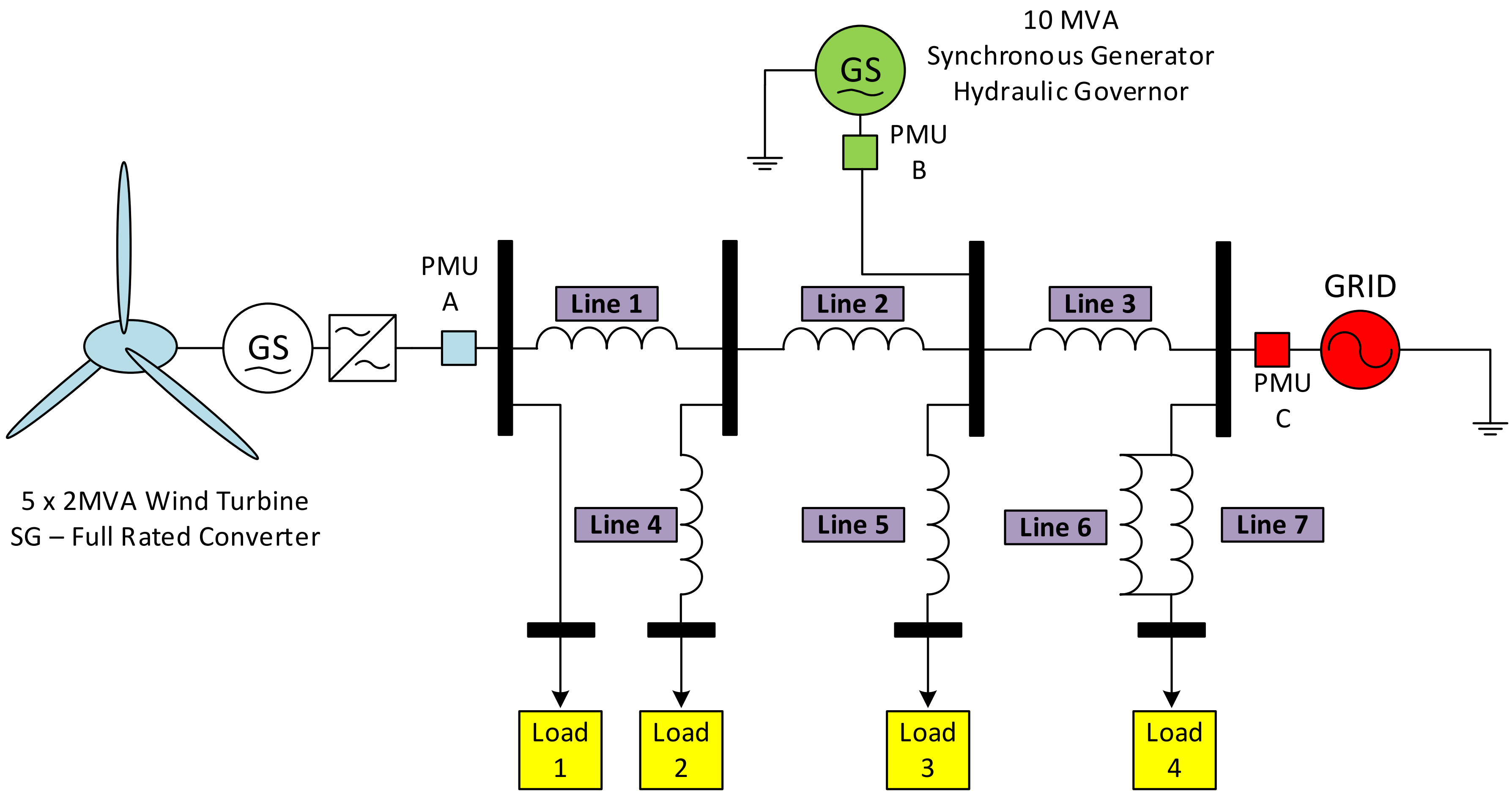
Urban circuits will be predominantly underground cable of varying capacity and branching, from zero length to possibly 500m maximum distance between source and furthest end point, but with total length maybe 1500m [need to check these guesses]. Loadings from zero to 300kVA.

Rural circuits will be a mixture of overhead lines and underground cable. OH line circuits can be longer, but generally not as heavily loaded. In rural areas there are also supplies provided by mural wiring (sometimes called under eaves wiring). This is not unknown in urban areas too – much of council housing between the wars in Manchester was (and is) supplied this way. Mural wiring typically supplies half a dozen properties and is supplied from a larger section overhead or underground main.

Related LOM work

- G2ELab and ERDF study
  - Survey on protection for undesired islanding
    - Short islanding events were reported but no longer than a couple of seconds
    - Islanding currently not seen as a major concern
    - The risk of islanding primarily depends on generation technology and point of connection
    - It is perceived that new European grid codes which will probably introduce enlarged frequency thresholds will increase the risk of unwanted islanding.
    - Future of LOM protection should be other than everything else already proposed.

Mixed generation technologies



Mixed DG Technologies – NDZ