Connecting Innovative Technologies Workshop

Principal Hotel, York
March 1, 2017

Welcome

Mark Drye
Director of Asset Management

Industry Update

Derek Fairbairn
System Design Manager

Objectives

- Share Northern Powergrid connection solutions
- Seek your views on other solutions that could help you to get connected
- Share Northern Powergrid innovation strategy and outlook
- Seek your views on emerging and innovative technologies
- Engage with you on network constraints

Ofgems projects on constrained networks

- Quicker More Efficient Connections
  - Improved visibility and availability of flexible connections
  - Development of an action plan for industry to progress more effective queue management

  www.ofgem.gov.uk/system/files/docs/2016/01/quicker_and_more_efficient_connections_jan_2016_-_final_29.01.2016_0.pdf

- Constrained networks update document
  - Ofgem published a consultation on 4 March 2016
  - Sought further information from DNOs in May and October 2016 to understand the position nationally
  - Ofgem have produced an update document with supporting detail on its findings

  www.ofgem.gov.uk/node/111071

  www.ofgem.gov.uk/node/111056

Ofgems update document

- This work focuses on connecting distributed generation and storage
- Ofgem's paper is to help stakeholders understand more about constraints including;
  – current status of constraints on the network
  – how DNOs are responding to constraints
  – it sets out Ofgem's expectations

Next steps - a smart, flexible energy system

- BEIS and Ofgem published a joint call for evidence on 10 Nov 2016
  - Ofgem will consider next steps on distribution constraint management and the interactions with the wider system in its forthcoming Spring Plan publication

https://www.ofgem.gov.uk/system/files/docs/2016/11/a_smart_flexible_energy_system_a_call_for_evidence.pdf

- In summary
  - The call for evidence considered how the management of the networks may need to evolve to meet the changing system needs.
  - New technologies and approaches need to enable efficient and flexible use of the network.
  - New approaches to help manage distribution network constraints and support an efficient wider system.
  - Greater clarity needed on how storage connects to the network.

Why do networks become constrained?

David van Kesteren
Senior Asset Management Engineer

Releasing capacity on the network

- Networks are traditionally designed for the worst-case credible scenarios
- Look at the potential to share the capacity at other times
- Methods to control generators under when capacity limits are reached

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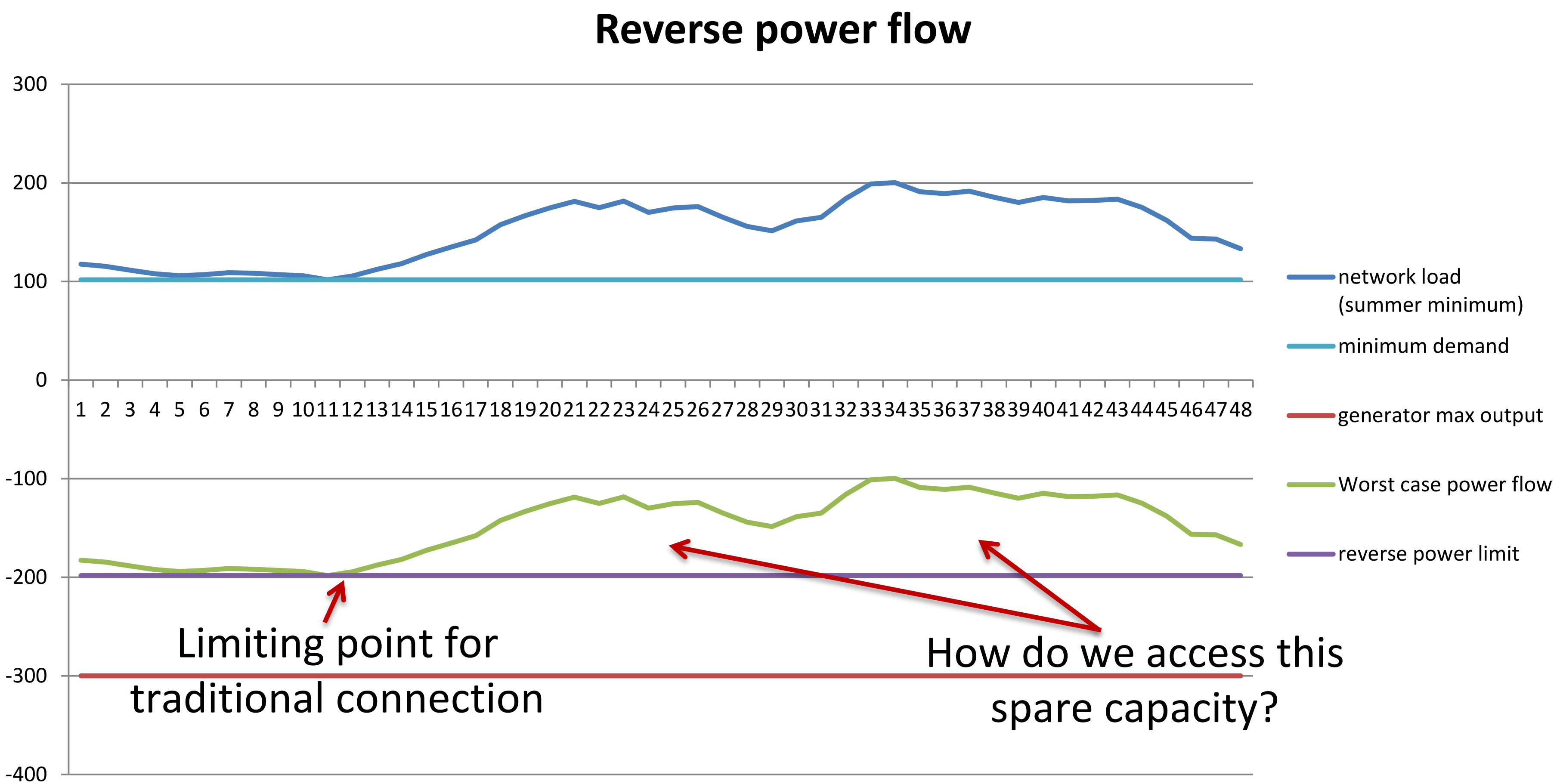
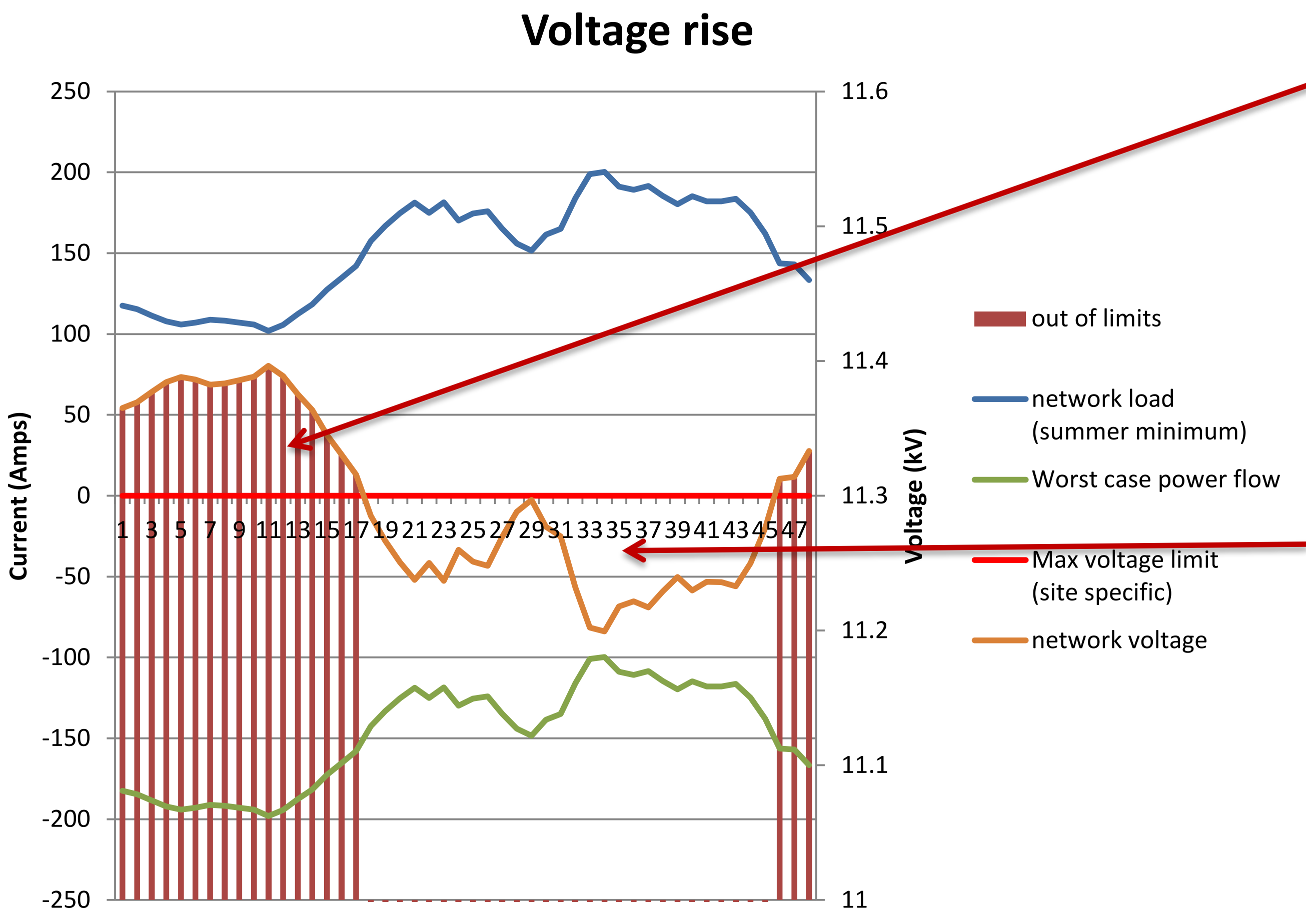
Accessing spare thermal capacity



Avoiding network over-voltage



- How do we avoid the over-voltages?
- And how to access the spare voltage headroom?

Voltage swings and fault level

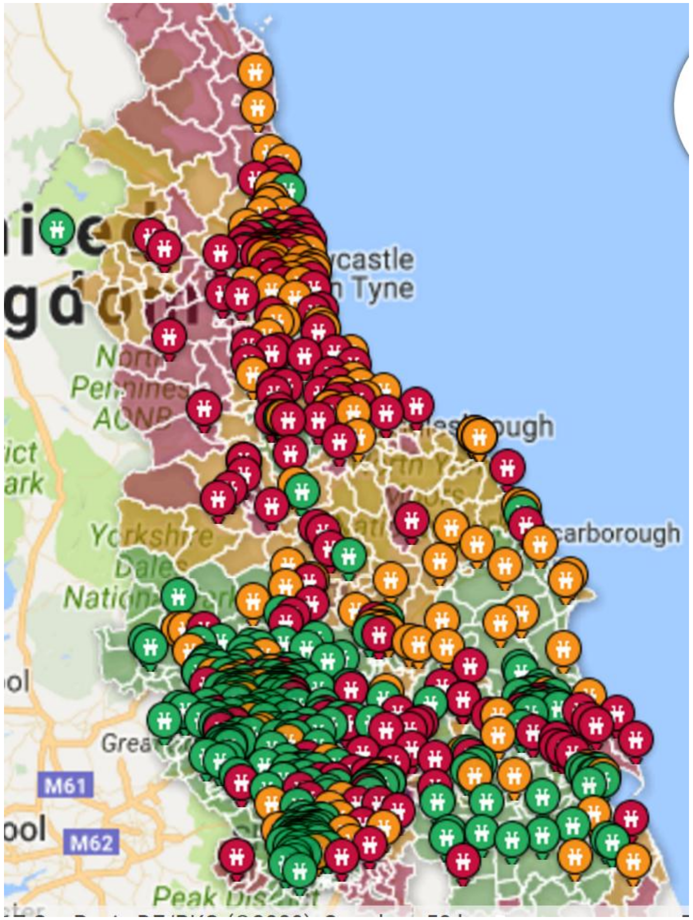
- What operational practices can we or the customer introduce to reduce or avoid voltage swings?
- Fault level management is challenging
  - Solutions currently expensive
  - Active fault level monitoring in development nationally

Tools for identifying spare network capacity

Rimnesh Shah
System Planning Engineer

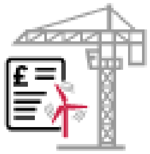
Generation availability maps

- GSP, BSP and Primary s/s plotted
- Interconnected topology for upstream/downstream effect
- Filter by capacity availability for larger developments
- Geographical information available
  - S/s location + postcodes served
- Asset Information available
- Network constraints provided with RAG status
- Cumulative quoted/contracted generation capacity provided
- http://www.northernpowergrid.com/generation-availability-map
- Similar demand availability map also published
- http://www.northernpowergrid.com/demand-availability-map



Contracted connections register

- All known generation recorded
  - By licence
  - GSP/BSP/Primary
- Filtered by type of generation
- Further filtered by Capacity vs Export
- Application status also provided to assist future connections



Contracted Connections Register
http://www.northernpowergrid.com/get-connected/

NORTHERN POWERGRID CONTRACTED CAPACITY REGISTER (Jan 2017)

License Area	Grid Supply Point	Supply Point	Primary Point	Generation Type	Connection (kV)	Capacity (kW)	Export (kW)	Status
Northeast	Blyth	Blyth 66kV	Ashington	Photovoltaic	HV (11)	4,000	4,000	Accepted
Northeast	Blyth	Blyth 66kV	Ashington	Onshore Wind	HV (11)	3,400	3,400	Connected
Northeast	Blyth	Blyth 66kV	Ashington	Landfill gas, sewage gas, biogas (not CHP)	HV (11)	1,000	890	Connected
Northeast	Blyth	Blyth 66kV	Ashington	Photovoltaic	HV (11)	76	76	Connected
Northeast	Blyth	Blyth 66kV	Ashington	Photovoltaic	HV (11)	2	2	Connected
Northeast	Blyth	Blyth 66kV	Benton Square 11kV	Photovoltaic	HV (11)	189	189	Connected
Northeast	Blyth	Blyth 66kV	Benton Square 11kV	Photovoltaic	HV (11)	50	50	Connected
Northeast	Blyth	Blyth 66kV	Cramlington 1_2_3	Photovoltaic	HV (11)	84	84	Connected
Northeast	Blyth	Blyth 66kV	Maddison Street	Offshore Wind	HV (11)	4,000	4,000	Connected
Northeast	Blyth	Blyth 66kV	Maddison Street	Photovoltaic	HV (11)	15	15	Connected
Northeast	Blyth	Blyth 66kV	Maddison Street	Photovoltaic	HV (11)	15	15	Connected
Northeast	Blyth	Blyth 66kV	Morpeth	Onshore Wind	HV (20)	15,000	15,000	Connected
Northeast	Blyth	Blyth 66kV	Morpeth	Photovoltaic	HV (20)	65	65	Connected
Northeast	Blyth	Blyth 66kV	Morpeth	Photovoltaic	HV (20)	53	53	Connected
Northeast	Blyth	Blyth 66kV	Morpeth	Photovoltaic	HV (20)	15	15	Connected
Northeast	Blyth	Blyth 66kV	Morpeth	Unknown	HV (20)	15	15	Connected
Northeast	Blyth	Blyth 66kV	Morpeth	Onshore Wind	HV (20)	15	15	Connected
Northeast	Blyth	Blyth 66kV	Morpeth	Photovoltaic	HV (20)	4	4	Connected
Northeast	Blyth	Blyth 66kV	Narec Windfarm	Offshore Wind	EHV (66)	99,800	99,800	Accepted
Northeast	Blyth	Blyth 66kV	Reservoir	Onshore Wind	HV (20)	275	275	Connected
Northeast	Blyth	Blyth 66kV	Seaton Burn 1	Landfill gas, sewage gas, biogas (not CHP)	HV (20)	2,200	2,200	Connected
Northeast	Blyth	Blyth 66kV	Seaton Burn 1	Photovoltaic	HV (20)	15	15	Connected
Northeast	Blyth	Blyth 66kV	Seaton Burn 1	Photovoltaic	HV (20)	15	15	Connected
Northeast	Blyth	Blyth 66kV	Seghill	Landfill gas, sewage gas, biogas (not CHP)	HV (11)	4,100	4,100	Connected
Northeast	Blyth	Blyth 66kV	Seghill	Unknown	HV (11)	65	65	Connected
Northeast	Blyth	Blyth 66kV	West Hartford	Onshore Wind	HV (11)	4,000	4,000	Connected
Northeast	Blyth	Blyth 66kV	West Hartford	Photovoltaic	HV (11)	15	15	Connected
Northeast	Blyth	Linton	Blue Sky Windfarm	Onshore Wind	EHV (66)	18,500	27,000	Connected
Northeast	Blyth	Linton	Blue Sky Windfarm	Onshore Wind	EHV (66)	8,200	8,200	Connected
Northeast	Blyth	Linton	Denwick	Mini CHP (<1MW)	HV (20)	180	180	Accepted
Northeast	Blyth	Linton	Denwick	Photovoltaic	HV (11)	150	150	Connected
Northeast	Blyth	Linton	Denwick	Photovoltaic	HV (11)	53	53	Connected
Northeast	Blyth	Linton	Denwick	Photovoltaic	HV (11)	42	42	Connected
Northeast	Blyth	Linton	Denwick	Photovoltaic	HV (11)	42	42	Connected
Northeast	Blyth	Linton	Linton 1_2	Onshore Wind	HV (20)	180	180	Accepted
Northeast	Blyth	Linton	Linton 1_2	Onshore Wind	HV (11)	50	50	Connected
Northeast	Blyth	Linton	Lynemouth	Biomass & Energy Crops (not CHP)	EHV (66)	20,000	20,000	Accepted
Northeast	Blyth	Linton	Lynemouth	Biomass & Energy Crops (not CHP)	EHV (66)	390,000	390,000	Connected

Long Term Development Statement (LTDS)

- Yearly publication to assist potential developers
- A geographic plan showing our 132kV and EHV systems
- Schematic diagrams detailing the connectivity and normal operating configurations of our distribution system
- Circuit, transformer data
- Load and Fault Level information
- Distributed generation data
- An outline of authorised system development proposals, including details of work proposed, expected timescales and impact on system
- The number of third-party enquiries for a connection

LTDS

Long Term Development Statement

https://www.northernpowergrid.com/long-term-development-statement

Granular data and other sources

This is the summated load (in amps) of the 11kV circuits	10:00:00	10:30:00	11:00:00	11:30:00	12:00:00	12:30:00	13:00:00	13:30:00	14:00:00	14:30:00	15:00:00	15:30:00	16:00:00	16:30:00	17:00:00	17:30:00	18:00:00	18:30:00	19:00:00
15/11/2013	208.497	199.118	195.603	192.818	192.086	194.87	199.558	198.532	197.507	196.627	204.833	217.58	262.996	295.526	304.897	293.768	290.248	282.188	269.74
16/11/2013	209.815	209.522	199.998	198.387	199.265	192.818	187.545	191.499	187.105	194.724	204.54	216.995	251.428	291.125	297.136	292.444	276.476	266.364	256.555
17/11/2013	221.682	219.925	226.518	231.647	239.559	225.054	219.633	222.123	222.123	225.199	238.092	260.218	292.737	317.796	320.867	304.754	292.009	279.703	266.224
18/11/2013	217.434	214.503	221.097	225.199	227.543	224.174	223.588	228.276	225.346	230.767	237.801	256.701	289.228	315.303	315.013	303.586	300.942	284.247	269.004
19/11/2013	210.987	210.694	211.426	217.14	208.79	201.17	203.807	203.661	208.936	217.874	221.243	243.662	291.276	329.08	333.327	325.856	310.912	302.847	293.183
20/11/2013	228.569	218.459	220.804	214.944	214.649	208.202	209.229	209.229	211.427	221.096	234.283	251.422	287.022	321.603	325.117	320.582	310.615	294.502	287.174
21/11/2013	228.423	229.888	223.001	213.918	208.644	203.808	209.815	208.789	211.28	217.873	226.811	242.489	278.966	311.053	316.62	310.319	304.751	290.25	278.969
22/11/2013	213.624	221.976	231.353	224.76	218.312	210.841	215.236	212.746	210.987	208.79	215.529	229.888	278.526	308.123	308.863	303	294.644	286.004	273.991
23/11/2013	162.49	167.764	167.764	170.401	173.323	168.343	171.281	206.591	213.184	210.255	215.676	229.595	265.923	293.908	306.809	303.147	289.666	274.576	261.092
24/11/2013	226.959	224.467	229.302	234.138	239.265	228.13	220.511	220.951	229.009	234.723	239.119	255.964	297.576	329.811	327.317	312.672	299.485	288.633	279.407
25/11/2013	230.914	236.628	234.431	229.156	223.149	222.709	227.544	227.838	225.786	229.302	235.456	256.848	302.113	325.853	330.542	319.114	309.447	296.699	286.885
26/11/2013	235.31	230.181	229.448	223.881	229.303	227.984	224.029	224.174	218.314	214.943	221.536	Calc Failec	292.891	330.538	335.677	323.651	311.346	300.355	286.291
27/11/2013	216.995	213.038	212.891	216.849	213.771	204.979	204.979	208.935	212.013	216.409	221.537	245.416	296.401	314.719	315.009	308.417	303.294	294.64	281.167
28/11/2013	221.976	223.734	225.346	220.364	216.994	216.994	216.407	219.192	215.09	218.167	227.104	249.518	291.716	312.814	314.719	305.483	301.529	286.004	275.449
29/11/2013	229.303	225.199	212.892	218.02	220.363	214.944	216.408	219.338	213.478	216.261	215.089	235.456	283.507	311.934	312.37	306.664	295.67	283.513	267.248
30/11/2013	230.767	223.589	225.346	223.588	217.58	207.764	204.54	203.661	199.998	200.583	212.745	239.119	272.67	299.336	309.301	303.581	294.498	283.069	267.535
01/12/2013	224.028	218.605	214.063	216.994	212.159	203.808	203.074	204.98	210.84	218.019	233.111	250.841	290.108	317.21	322.483	308.56	296.111	286.59	274.573
02/12/2013	235.162	231.49	232.377	232.666	228.716	225.053	221.537	223.001	222.563	231.061	241.752	260.356	307.388	334.495	336.4	325.857	312.077	300.508	291.276
03/12/2013	226.518	224.028	228.125	231.347	228.13	223.735	222.123	226.665	223.442	227.397	229.303	254.498	301.384	325.712	325.119	323.217	311.057	291.279	286
04/12/2013	222.415	217.141	218.312	215.969	208.057	204.687	211.573	209.962	211.428	217.433	226.957	253.324	298.016	323.505	326.584	321.893	317.207	305.192	289.814
05/12/2013	246.005	251.719	239.549	238.824	243.659	231.353	222.708	225.346	221.244	224.32	235.456	257.723	301.527	328.055	328.931	319.557	314.718	320.429	315.595
06/12/2013	256.554	262.123	255.236	254.063	251.426	246.445	248.642	254.503	254.065	262.122	266.373	286.587	334.205	351.784	355.009	345.193	337.425	322.927	316.034
07/12/2013	240.145	234.577	230.768	230.913	225.199	217.727	211.427	209.668	217.14	223.441	231.939	245.858	277.801	303.294	315.748	311.495	298.748	286.291	275.306
08/12/2013	232.086	232.672	234.577	237.068	239.559	238.679	244.54	242.929	248.644	255.09	259.331	281.307	310.035	330.251	332.595	316.919	305.927	294.938	281.308

- Half hourly data for constraint analysis and customer financial modelling
- Available asset outage data
- Access to our system records
- Customer surgeries and dedicated engineers

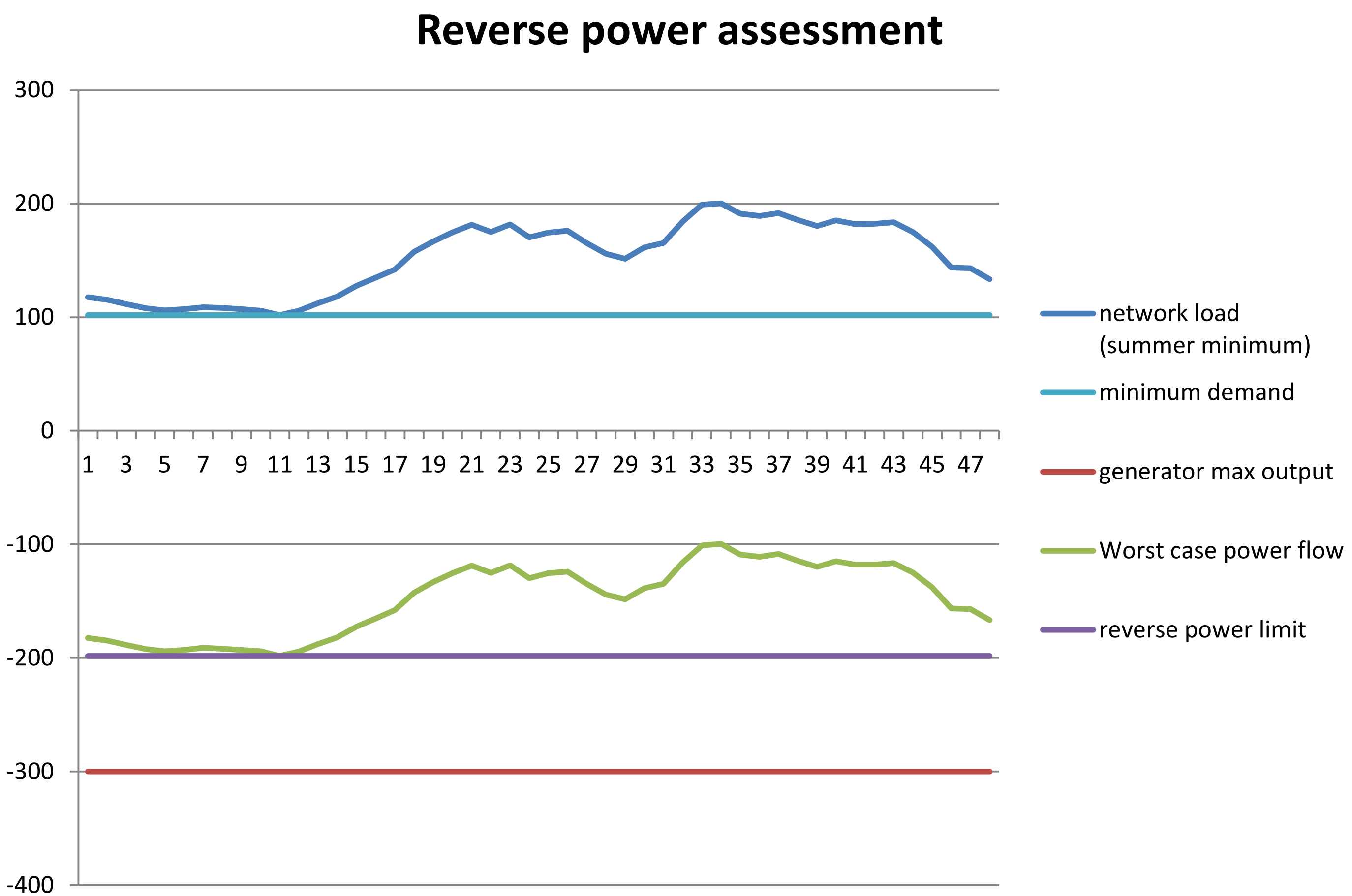
Solutions for constrained networks

David van Kesteren
Senior Asset Management Engineer

Main reasons for constraints

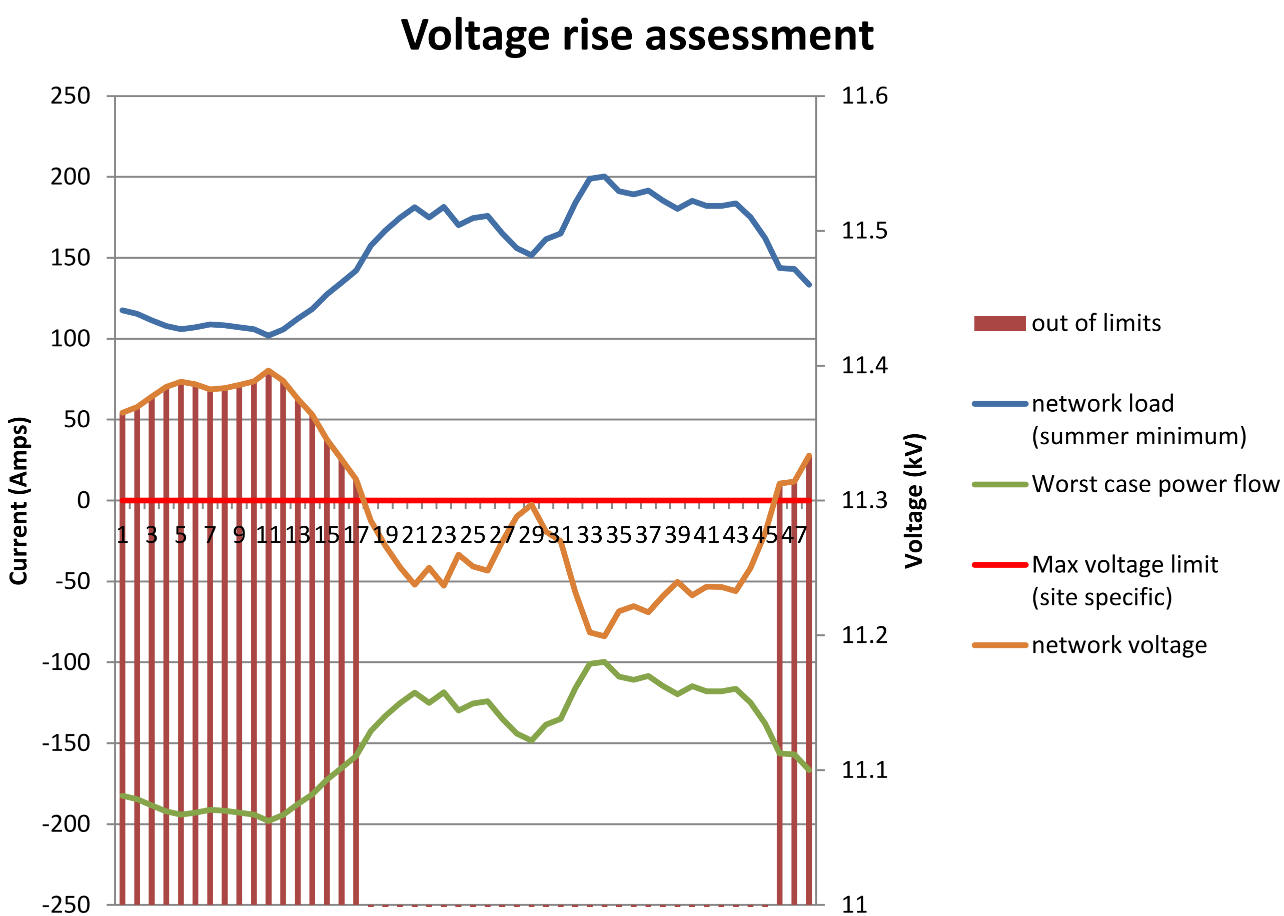
- Reverse power thermal (circuit capacity)
- Voltage rise (steady state)
- Step voltage changes due to power swings
- Fault level infeed
- Harmonics (rarely)

Thermal limits



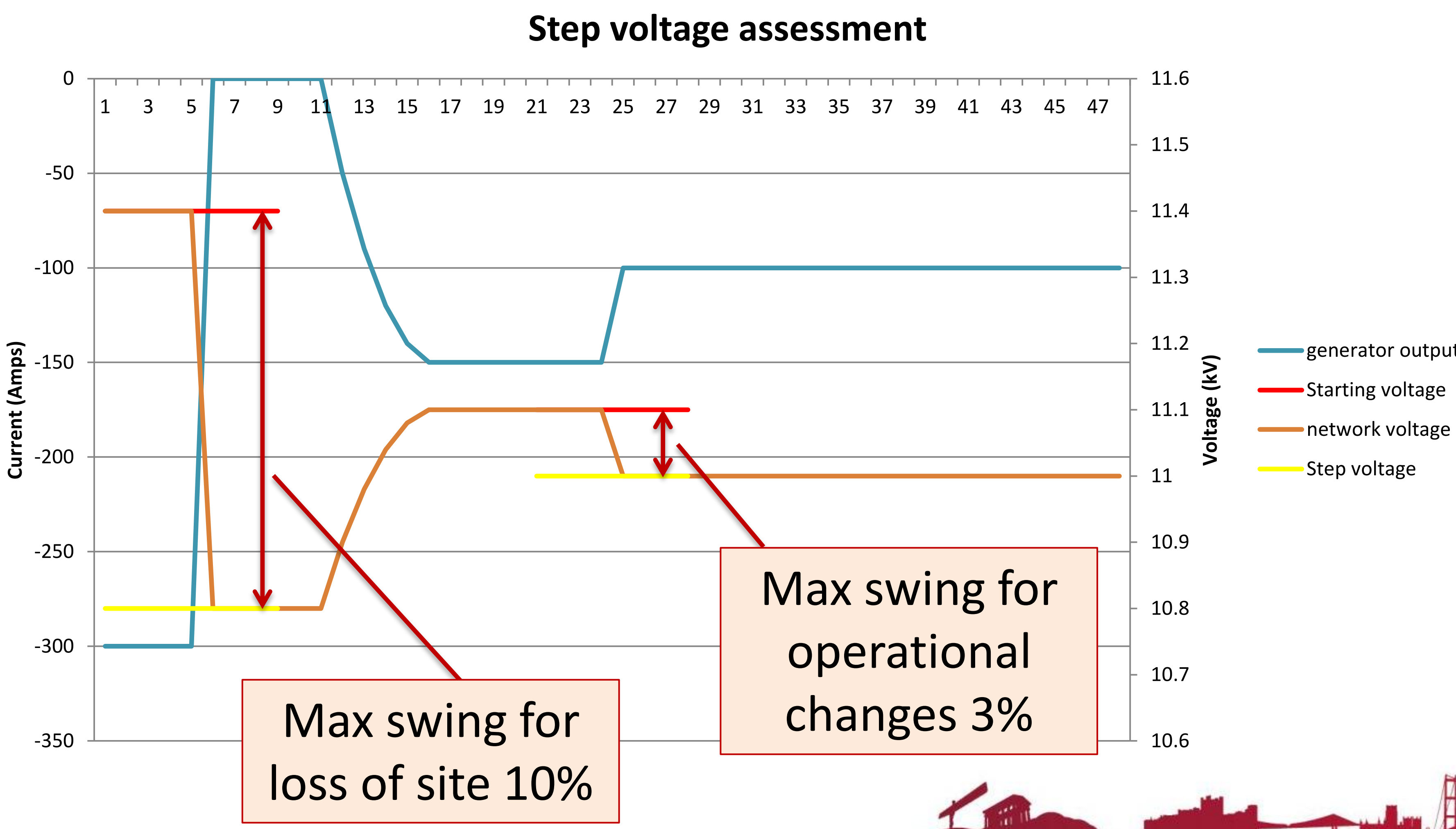
Assessment based on maximum generator output at times of network minimum demand

Steady state voltage rise

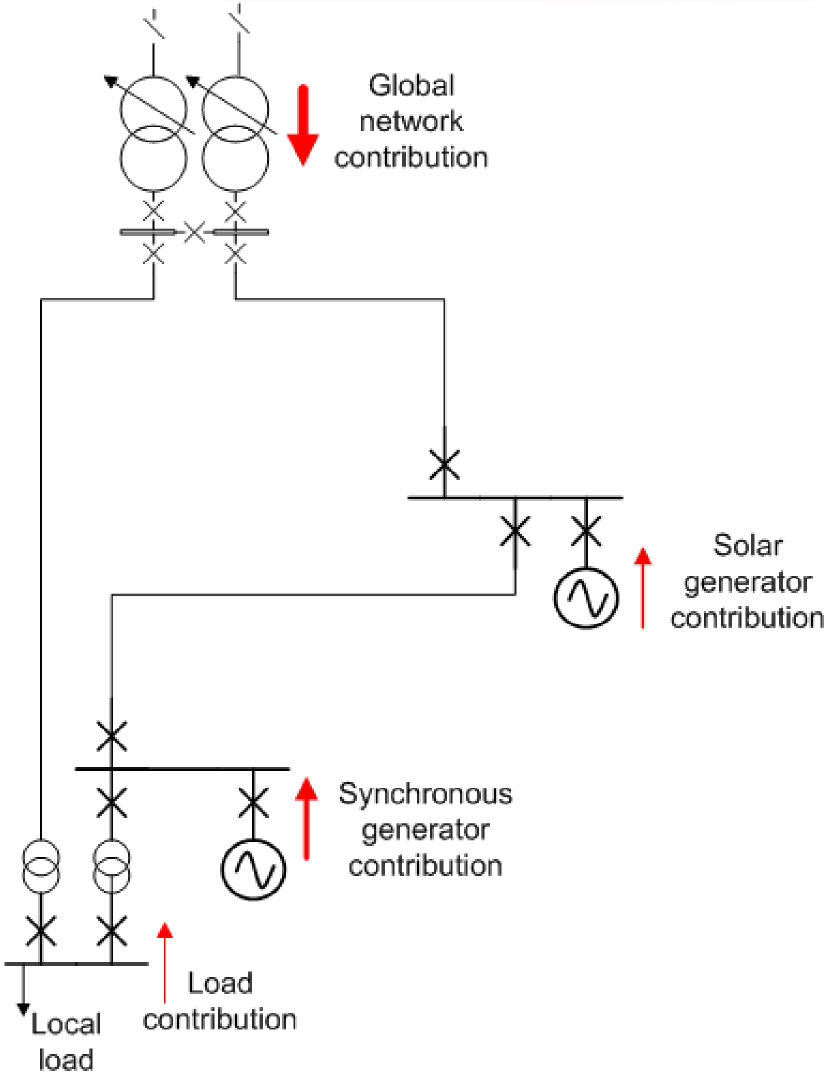


- Voltage must stay within statutory limits locally and remotely
- Assessment based on maximum generator output at times of network minimum demand

Step voltage - comply with Eng. Rec P28



Fault level assessment



- Cumulative effect of <u>all</u> connected generation
  - and load…

Harmonics

- Cumulative impact
- Measurements taken post-acceptance
- Mitigation generally on customer side
  - Compliance with Eng. Rec G5

Examples of 11kV solutions

James Nunns/

Rimnesh Shah

Innovative generation

Examples of innovative generation schemes:

1) Hydro and battery scheme installed as part of a standalone generation site
2) Firm / unfirm solar scheme connected to a large industrial premises
3) Export limiting scheme installed on a new Anaerobic Digester (AD) site
4) Solar and wind generation connection utilising demand profiling
5) PV + CHP scheme with voltage constraint connection

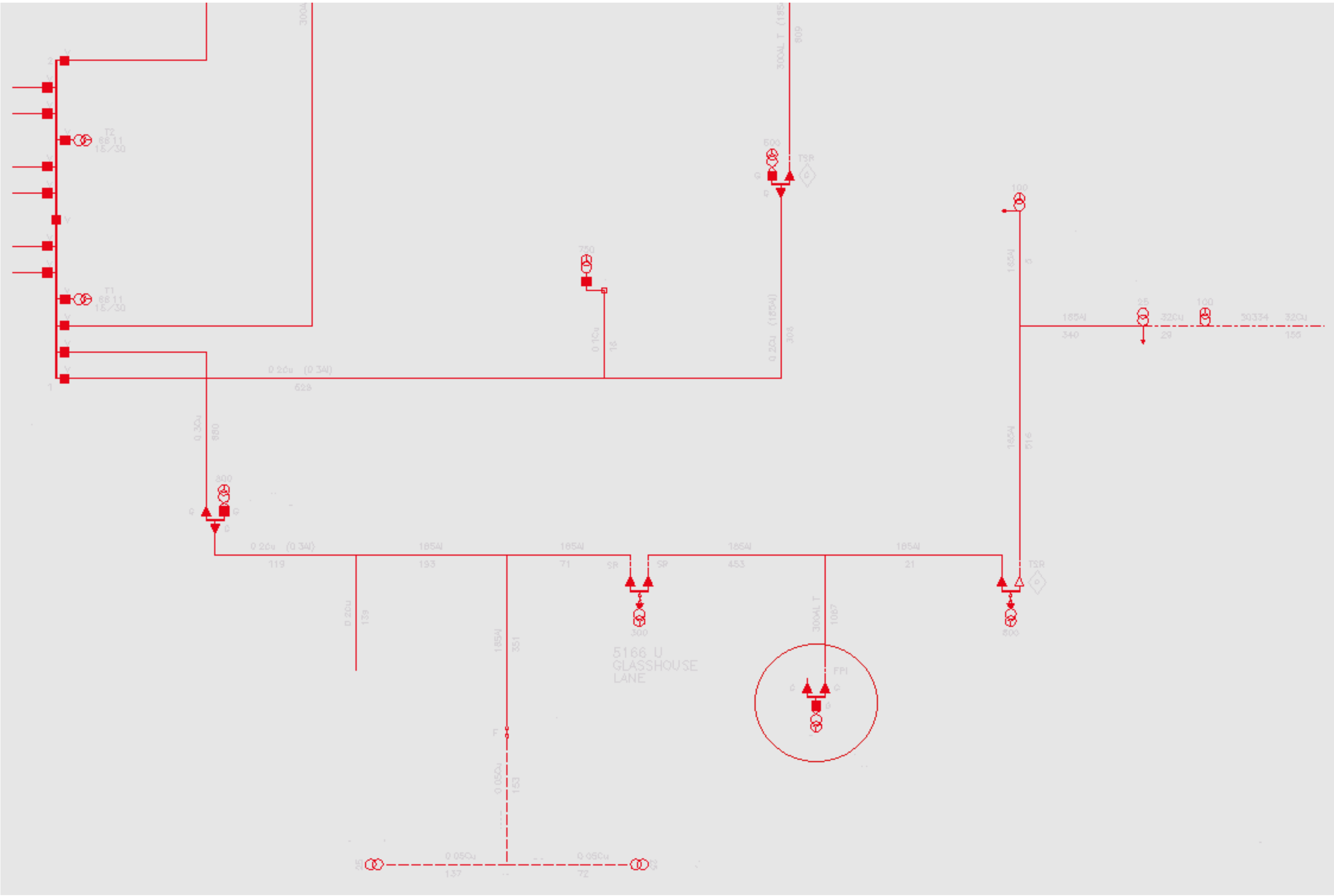
Connect on existing – hydro and battery

1) Hydro and battery scheme installed as part of a standalone generation site

- Initial request - Connection of a 300kW hydro generator to the local Northern Powergrid 11kV network.
- Proposals - Supply provided via a teed connection. The design allowed for the full export via a switched alternative connection.
- Work was completed summer 2015.

Connect on existing – hydro and battery

11kV schematic diagram



Connect on existing – hydro and battery

- New request - In 2016 a request was received to increase the site connection agreement for 1000kW import and 1300kW export.
- Proposals - A site meeting was held with both the Hydro company and the battery operator to agree the site requirements and how best to utilise the existing installation.

- Network studies indicated that the proposed scheme could be accommodated via the existing 11kV point of common coupling without any restrictions being imposed, on both the normal and alternative circuits.
- Work is required to change the existing switchgear to accommodate the proposed connection, and a project is being finalised to carry out work later on in the year by Northern Powergrid delivery department in co-ordination with all parties on site.

Constraint on alternative feeder – load + solar

2) Firm / unfirm solar scheme connected to a large industrial premises

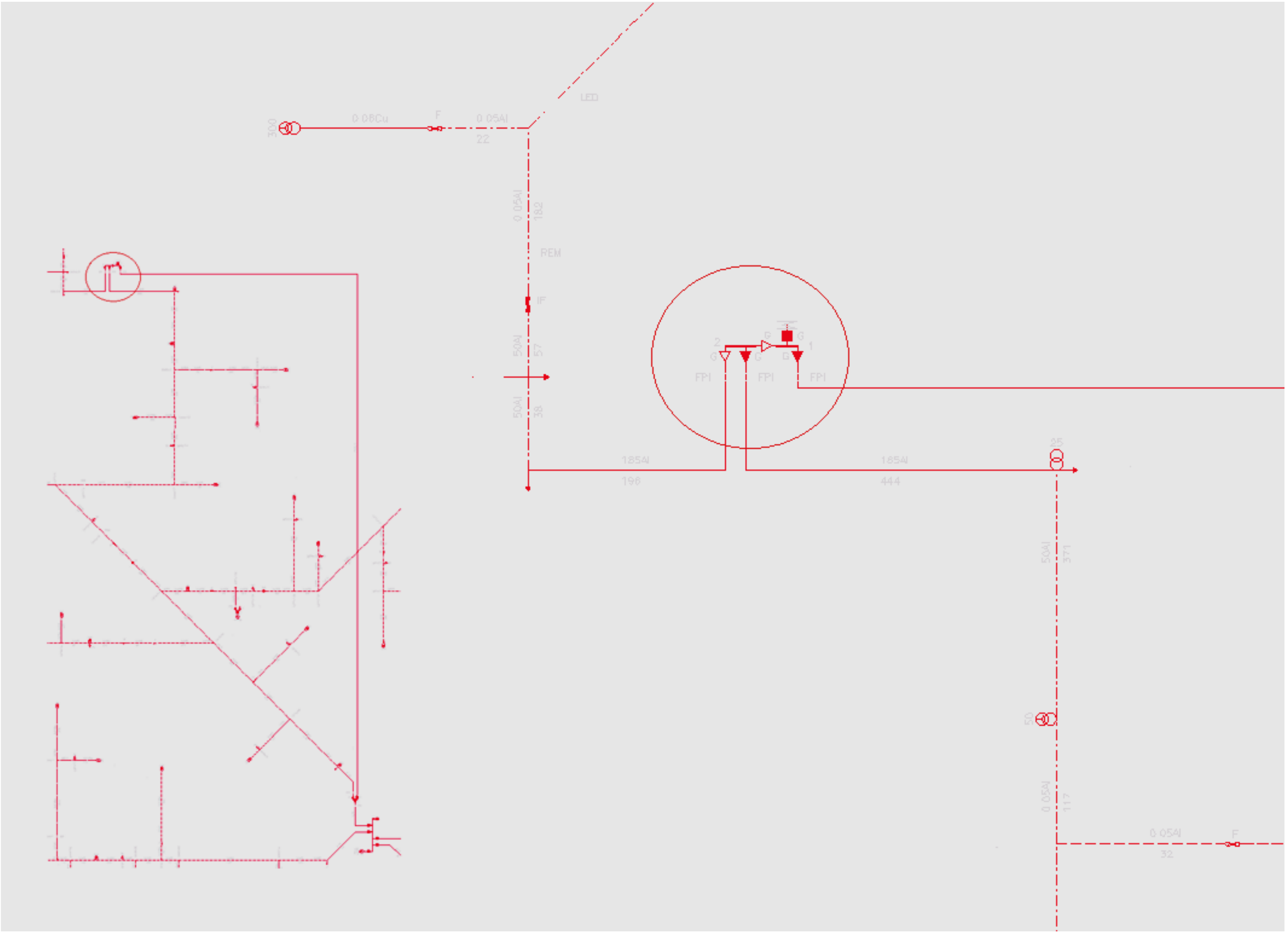
- Request - To install 5MW of solar generation on an existing factory roof, and increase the import agreement to 3.5MVA.
- Existing factory site with a switched firm import agreement for 2MVA.

Constraint on alternative feeder – load + solar

- Proposal - The proposed design involved installing a new dedicated 11kV circuit from the local primary substation that would be able to accommodate the 5MW of generation and the 3.5MW via an unfirm agreement.
- Upgrading the alternative feeder was considered to be too expensive by the customer.
- During maintenance or abnormal network conditions the factory supply is constrained to a maximum 2MW import / export.
- The customer was responsible for installing a suitable robust load management scheme that limited the import and export for the site. The scheme pre-dated the ENA Engineering Recommendation of export limiting schemes. It was formally approved prior to commissioning.

Constraint on alternative feeder – load + solar

11kV schematic diagram



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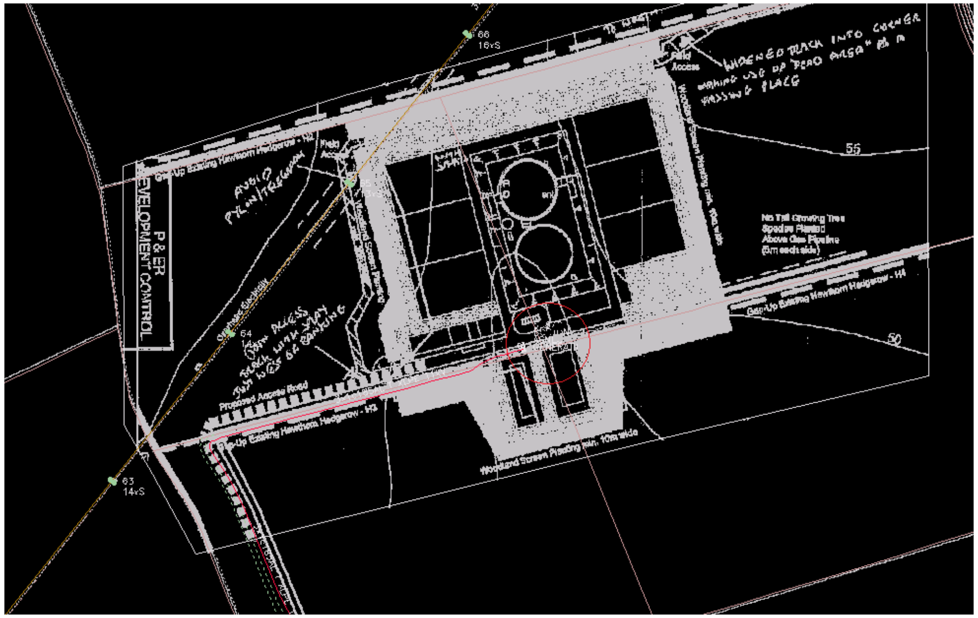
Export limiting scheme – load + biogas

3) Export limiting scheme installed on a new Anaerobic Digester site

- Request – site import 650kW with an export limited to 190kW due to Northern Powergrid network limitations

- The plant will produce bio-methane from agricultural products such as maize, wheat straw and pig and poultry manures.

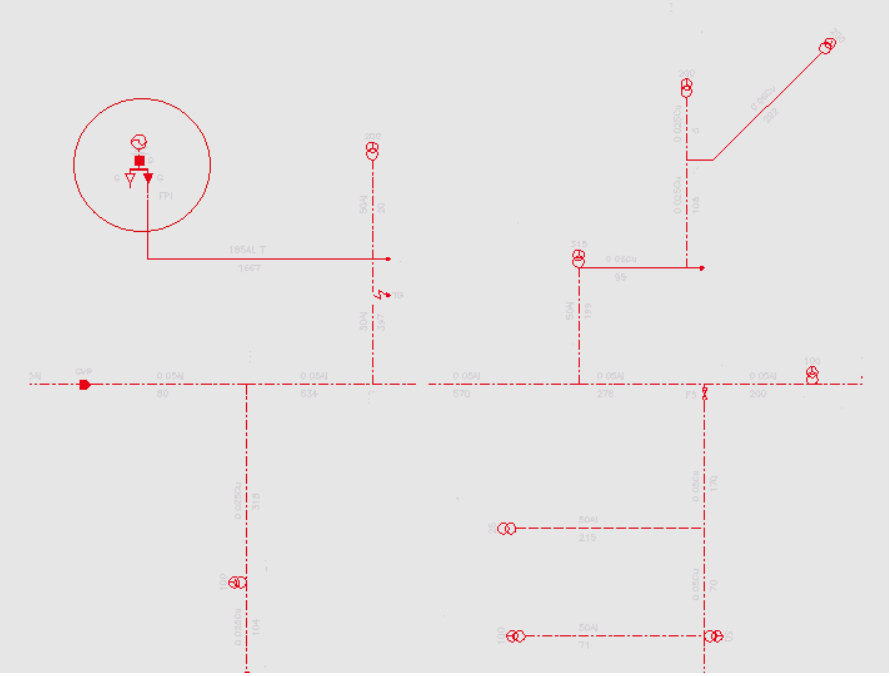
- Some of the bio-methane will be burnt in generation via the proposed 499kW CHP unit to power the site, but the majority will be injected into the national grid gas network and consumed by homes and businesses.



Export limiting scheme – load + biogas

- Proposals – A supply was provided via a teed connection into the local HV network by installing approximately 2kM of HV cable to the proposed site.
- A bulk HV metered substation was installed on site with conventional generation protection and a reverse power flow relay to limit the export from site to a maximum 190kW.
- To ensure that the customers connection remained within the agreed limits, the customer also installed equipment on their side of the connection to limit their generation output from the site.

11kV schematic diagram

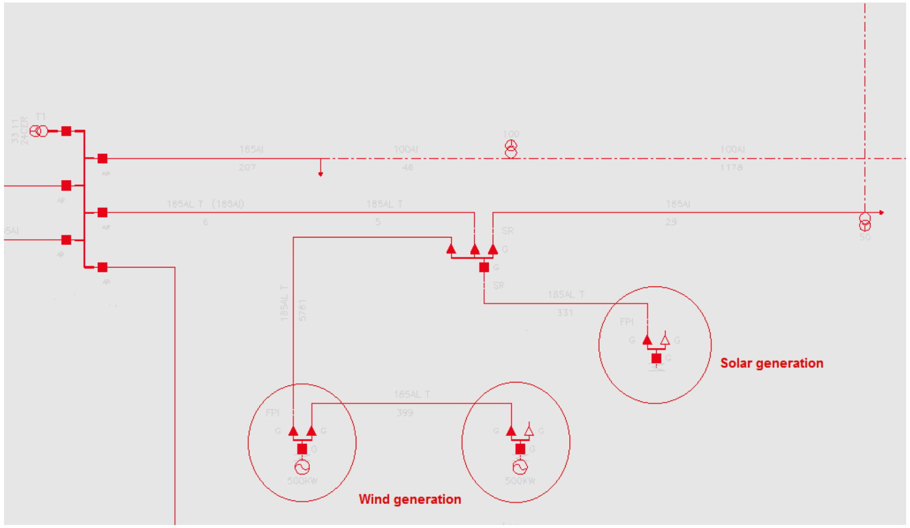


Generation profiling – solar + wind

4) Solar and wind generation connections utilising demand profiling

- Request - A landowner wanted to connect up to 1.5MW of wind turbines to the local primary substation.
- An existing 5MW solar site was already fed from the single transformer primary substation and notionally utilised all of the reverse power capability at the primary substation.
- To provide the wind turbine connection, demand profiling was carried out to ascertain the amount of reverse power flow expected from the solar farm and proposed wind turbines.
- It was concluded that 1.5MW of wind generation could be connected without the need to restrict the output from either site.

11kV schematic diagram



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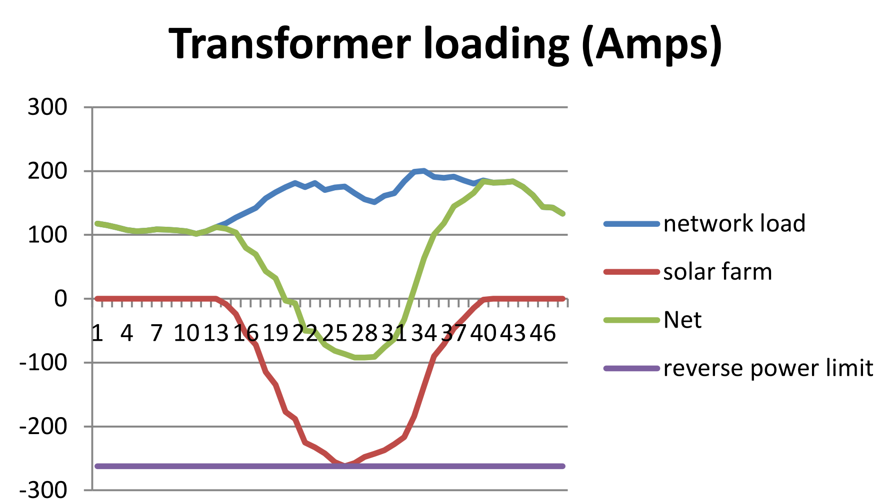
Generation profiling – solar + wind

- Example of the information used to carry out the demand profile study, solar and wind generation output vs primary substation demand profile:

This is the summated load (in amps) of the 11kV circuits	10:00:00	10:30:00	11:00:00	11:30:00	12:00:00	12:30:00	13:00:00	13:30:00	14:00:00	14:30:00	15:00:00	15:30:00	16:00:00	16:30:00	17:00:00	17:30:00	18:00:00	18:30:00	19:00:00
15/11/2013	208.497	199.118	195.603	192.818	192.086	194.87	199.558	198.532	197.507	196.627	204.833	217.58	262.996	295.526	304.897	293.768	290.248	282.188	269.74
16/11/2013	209.815	209.522	199.998	198.387	199.265	192.818	187.545	191.499	187.105	194.724	204.54	216.995	251.428	291.125	297.136	292.444	276.476	266.364	256.555
17/11/2013	221.682	219.925	226.518	231.647	239.559	225.054	219.633	222.123	222.123	225.199	238.092	260.218	292.737	317.796	320.867	304.754	292.009	279.703	266.224
18/11/2013	217.434	214.503	221.097	225.199	227.543	224.174	223.588	228.276	225.346	230.767	237.801	256.701	289.228	315.303	315.013	303.586	300.942	284.247	269.004
19/11/2013	210.987	210.694	211.426	217.14	208.79	201.17	203.807	203.661	208.936	217.874	221.243	243.662	291.276	329.08	333.327	325.856	310.912	302.847	293.183
20/11/2013	228.569	218.459	220.804	214.944	214.649	208.202	209.229	209.229	211.427	221.096	234.283	251.422	287.022	321.603	325.117	320.582	310.615	294.502	287.174
21/11/2013	228.423	229.888	223.001	213.918	208.644	203.808	209.815	208.789	211.28	217.873	226.811	242.489	278.966	311.053	316.62	310.319	304.751	290.25	278.969
22/11/2013	213.624	221.976	231.353	224.76	218.312	210.841	21											.004	273.991
23/11/2013	162.49	167.764	167.764	170.401	173.323	168.343	17											.576	261.092
24/11/2013	226.959	224.467	229.302	234.138	239.265	228.13	22											.633	279.407
25/11/2013	230.914	236.628	234.431	229.156	223.149	222.709	22											.699	286.885
26/11/2013	235.31	230.181	229.448	223.881	229.303	227.984	22											.355	286.291
27/11/2013	216.995	213.038	212.891	216.849	213.771	204.979	20											94.64	281.167
28/11/2013	221.976	223.734	225.346	220.364	216.994	216.994	21											.004	275.449
29/11/2013	229.303	225.199	212.892	218.02	220.363	214.944	21											.513	267.248
30/11/2013	230.767	223.589	225.346	223.588	217.58	207.764	2											.069	267.535
01/12/2013	224.028	218.605	214.063	216.994	212.159	203.808	20											36.59	274.573
02/12/2013	235.162	231.49	232.377	232.666	228.716	225.053	22											.508	291.276
03/12/2013	226.518	224.028	228.125	231.347	228.13	223.735	22											.279	286
04/12/2013	222.415	217.141	218.312	215.969	208.057	204.687	21											.192	289.814
05/12/2013	246.005	251.719	239.549	238.824	243.659	231.353	22											.429	315.595
06/12/2013	256.554	262.123	255.236	254.063	251.426	246.445	24											.927	316.034
07/12/2013	240.145	234.577	230.768	230.913	225.199	217.727	21											.291	275.306
08/12/2013	232.086	232.672	234.577	237.068	239.559	238.679	2											.938	281.308

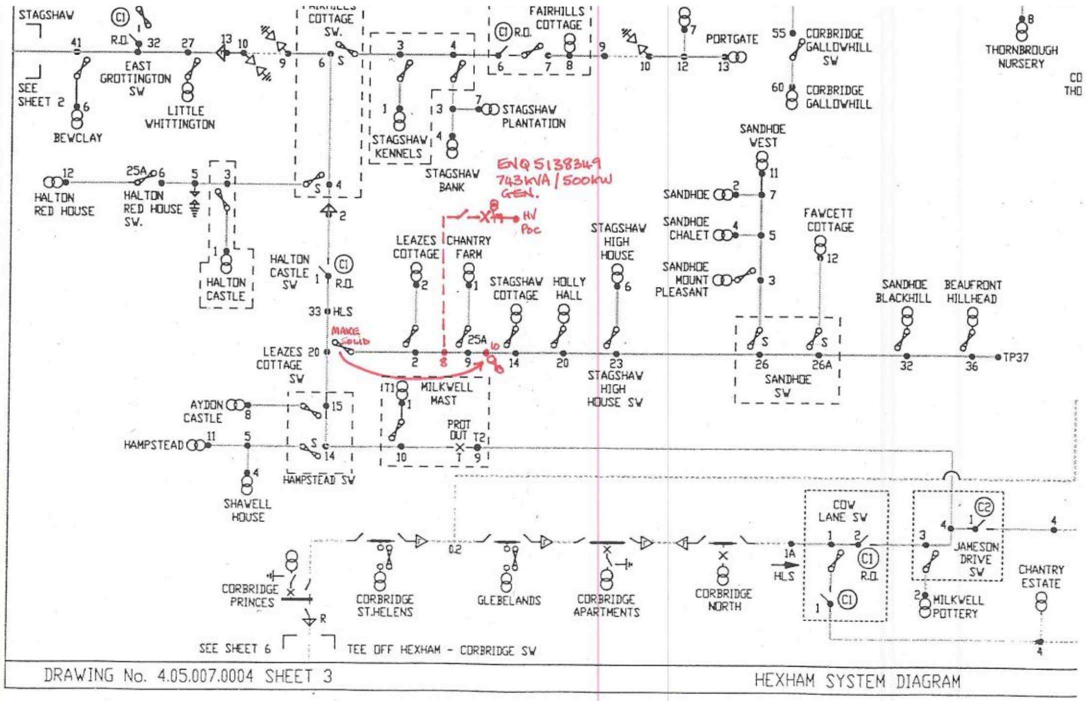


NORTHERN POWERGRID

PV + CHP scheme with voltage constraint

5) Generation connections offered with a voltage constraint

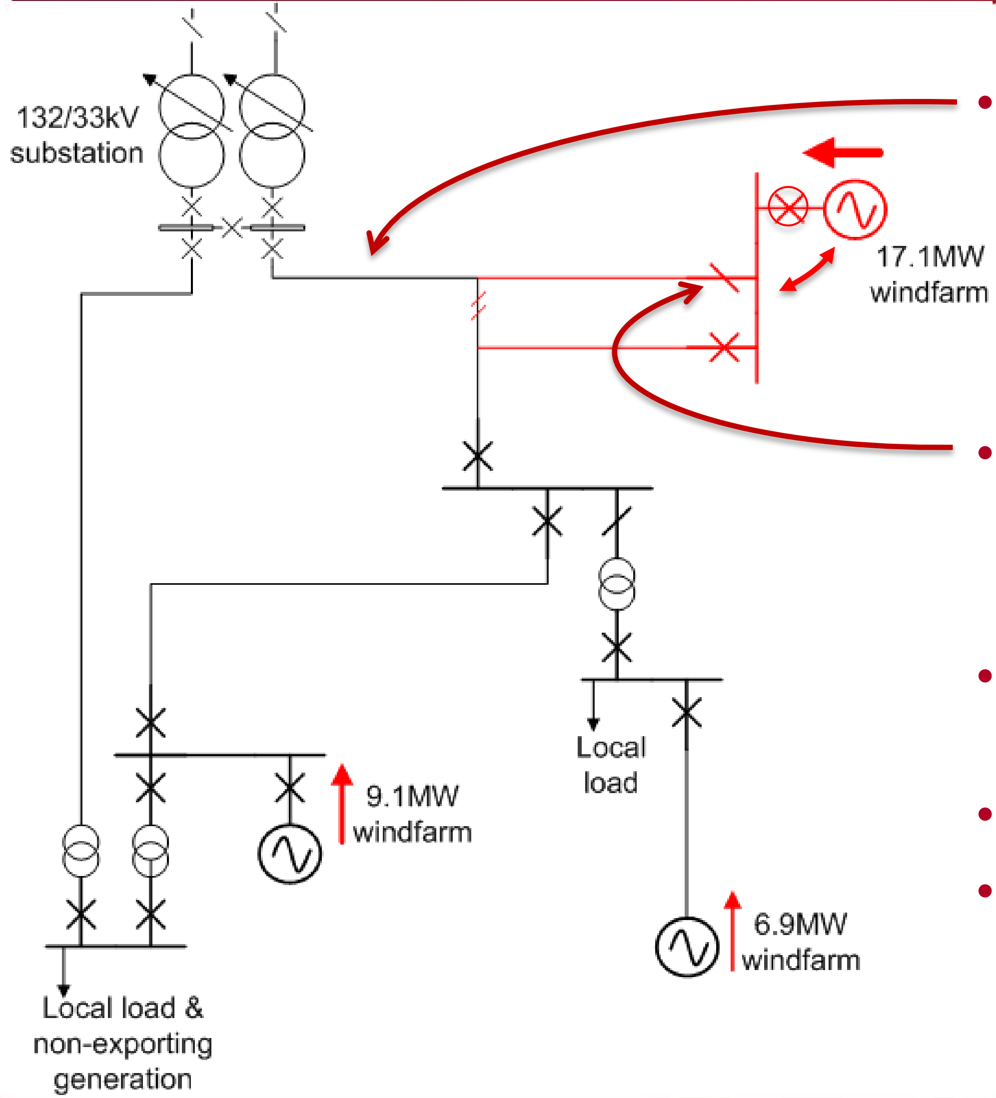
- Request - A farmer upgraded supply and requested connection of 200kW CHP and 250kW PV
- Proposal - Due to the different types of generation and different minimum demand were considered rather than absolute value
- Connection with upper voltage limit of 20.2kV was offered
- Voltage control with the customer to ensure network volts within limits
- Half hourly data provided for constraint analysis
- Additional overvoltage relay on Northern Powergrid side



Single customer active measurement and control

David van Kesteren
Senior Asset Management Engineer

Single customer active measurement and control



- Worst case reverse power flow exceeds summer circuit rating of 21.8MVA
- Install active directional measurement of load on circuit at the customer's metering substation
- Share data with customer
  - Customer self manages output
- Provide overload alarm
- Trip metering CB for sustained overload

Active Network Management

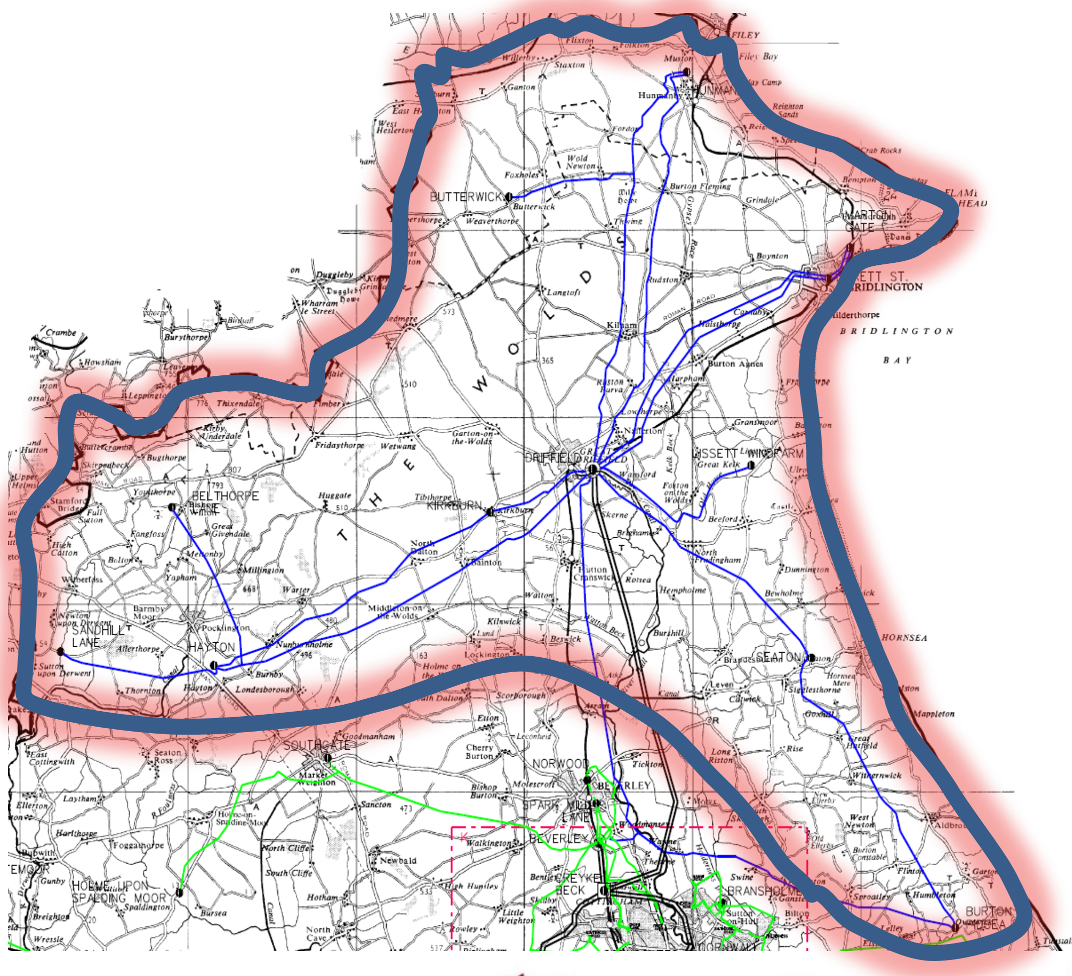
Ian Fletcher
System Planning Engineer

ANM - Scheme build

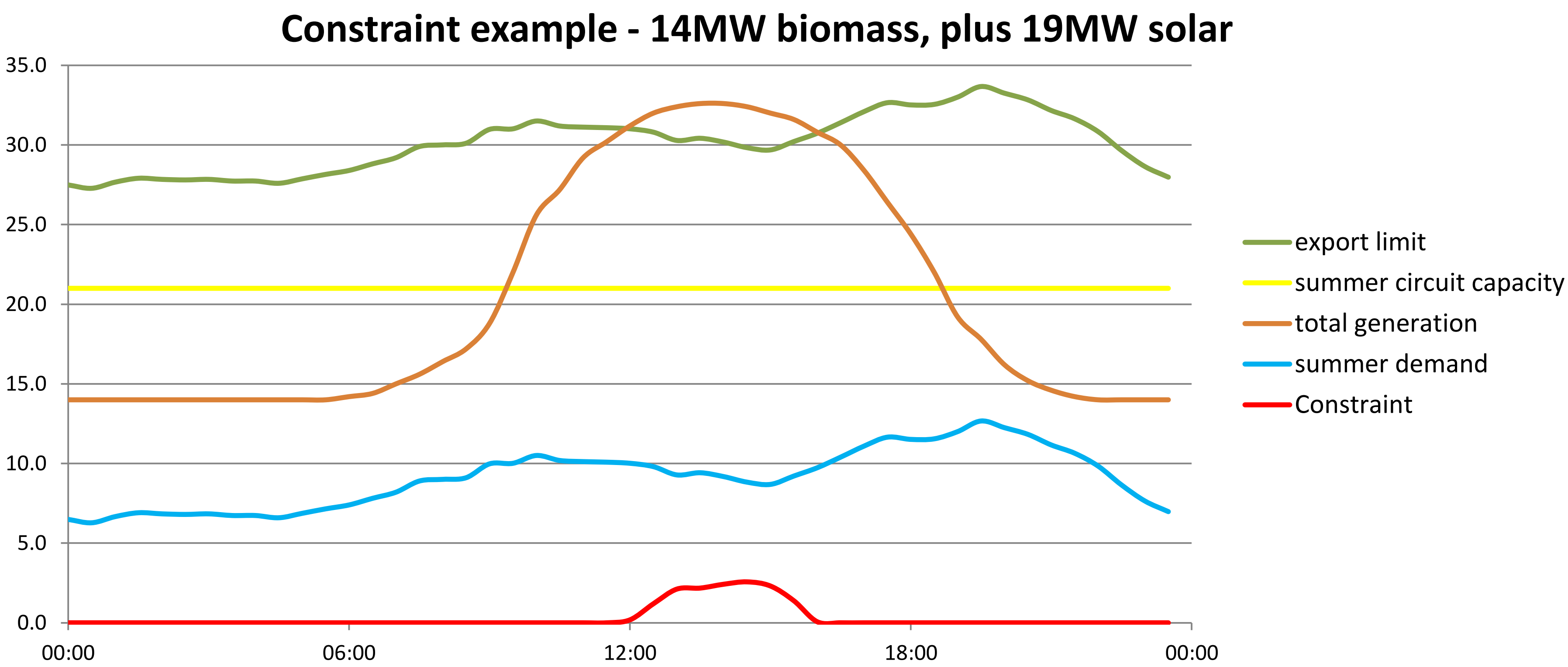
- What does ANM do?
  - Dynamically controls one or more generating sites to increase site export capability where a network capacity or voltage constraint does not allow 24/7 operation at maximum output.
- What does an ANM scheme consist of?
  - **Coordinating controller:** the brain of the scheme, ultimately used to control all ANM customers as they connect
  - **Local controller:** customer specific, does what the brain tells it to do
  - **Measurement points:** used by the coordinating controller determine one or more customers' target set-point
  - **Comms links:** required to knit the whole scheme together. Each link may support the control of one or more customers
  - **Thermal protection: s**eparate from the ANM kit, there to protect our assets if the ANM scheme malfunctions. Required where one or more customers could overload Northern Powergrid assets if ANM fails.

ANM at Driffield

- Thermal circuit capacity constraints
- Transformer reverse power flow constraints
- Costly to reinforce i.e. uprate overhead lines and/or replace transformers



ANM – Example constraint



ANM increases network utilisation by liberating capacity headroom in real-time

ANM benefits and drawbacks

- **Pros**
  - Minimum demand only occurs for short periods in the year
  - As network demand increases more generation can be released
  - Unused contracted generation capacity can be utilised by other generators
  - Significantly cheaper than conventional reinforcement
  - Releases more capacity at Driffield than can be economically achieved through conventional reinforcement
- **Cons**
  - Generation output must be flexible
  - No absolute guarantee of level of network availability
  - Small-scale generation (LV) may erode available headroom over time
  - Levels of curtailment will be higher for later entrants (LIFO principle)

Export Limiting Schemes

David van Kesteren
Senior Asset Management Engineer

Export limiting schemes

- New national Engineering Recommendation G100
- Northern Powergrid internal Code of Practice to mirror G100
- Functional specification for scheme requirements
- Customer responsible for proof of design and installation
- Total generation limited to 125% of import or export agreement
- Default export capacity for LV connections 16A per phase
- G59 application still required
- Customer owned and operated

Total generator size	Witnessed testing?
<50kW	Not required
50-200kW	Discretionary
>200kW	Compulsory

Roundtable exercise

- What more could Northern Powergrid do to;
  (a) help you get connected?
  (b) improve your project viability?
- 10 minutes please…
- Feedback to the group

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Technical challenges of connecting storage systems

David van Kesteren
Senior Asset Management Engineer

Technical challenges from storage

- Key principles remain the same, but there are additional considerations:
  - What level of security of supply is required?
  - Fast response power swings vs 3% step voltage limit
    - Ramp changes are less onerous
  - Limited battery capacity may allow consideration of cyclic circuit ratings for some sites
  - Small customers might not want to export power but they might install more than 3.68kW of combined generation, exceeding G83 limit

Large Scale Enhanced Frequency Response BESS

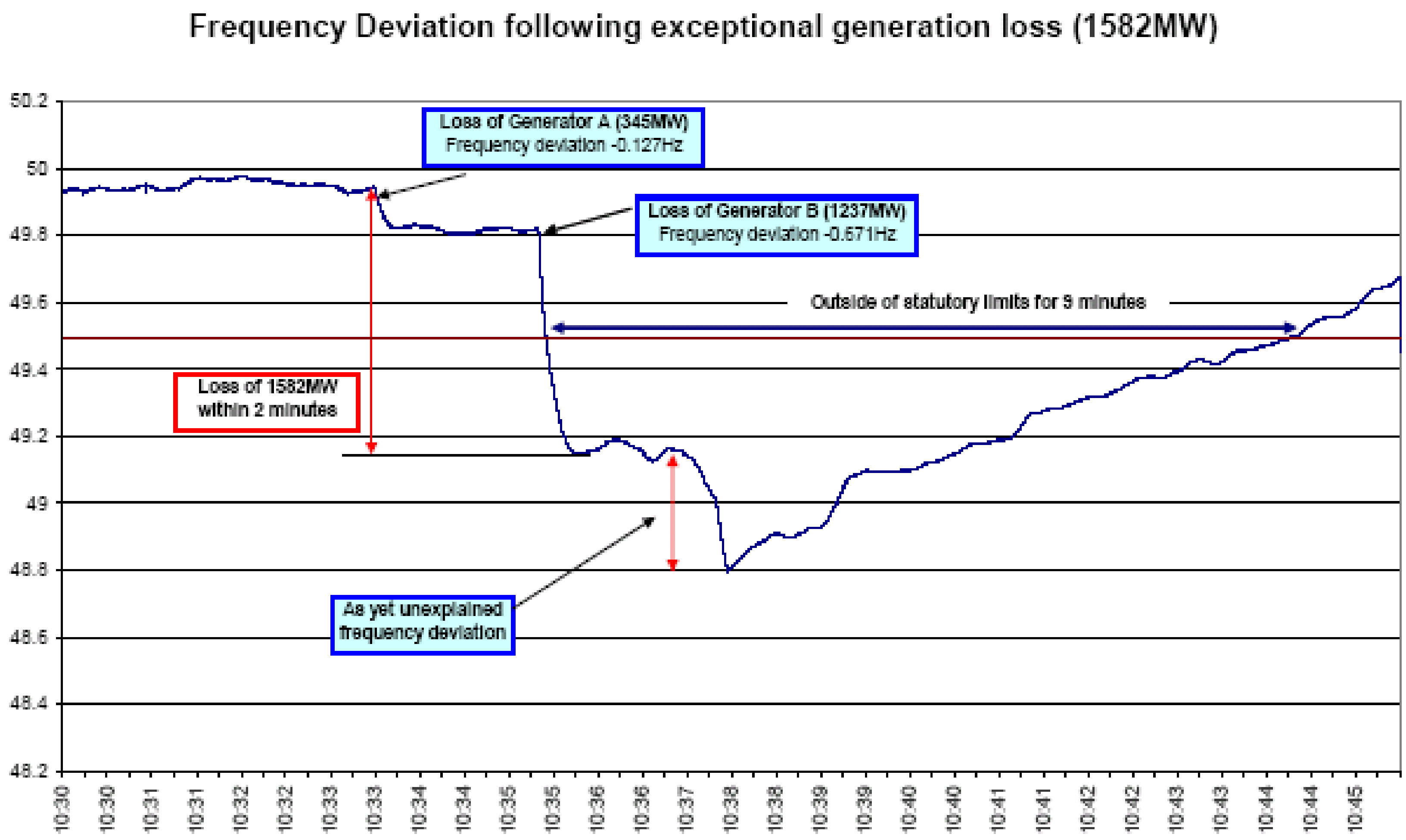
Ruth Peacock

Protection Engineer

Design considerations

- Thermal Impact?
- System Fault Level Impact?
- Voltage Impact?

Frequency control



Frequency control

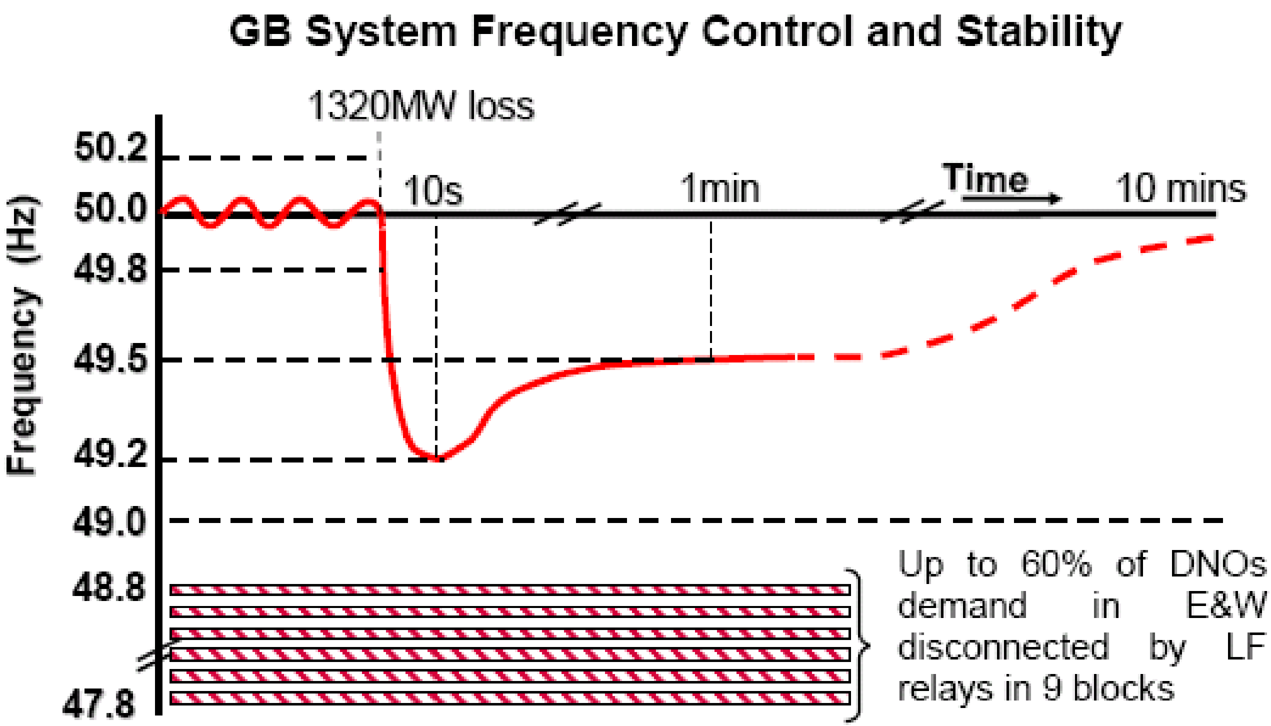
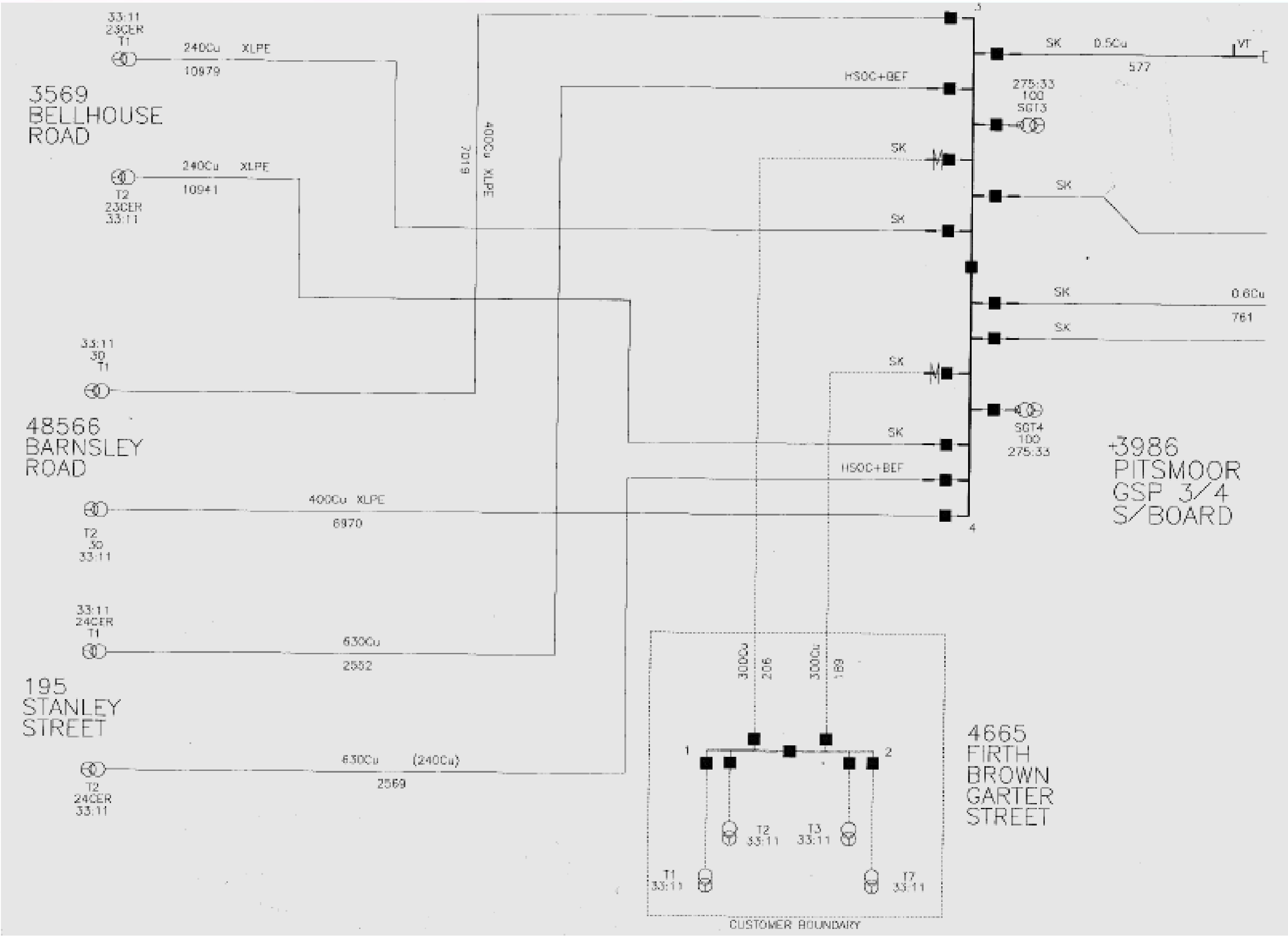


Figure 1 illustrates the frequency control philosophy and frequency stability of the GB power system. In addition, where the initial frequency is close to the lower operational limit of 49.8Hz at the time of a 1320MW loss, the lowest planned frequency would be 49Hz. This would still restrict the maximum frequency deviation to 0.8Hz and provide a 0.2Hz margin above the level where the LFDD scheme is designed to operate and disconnect demand.

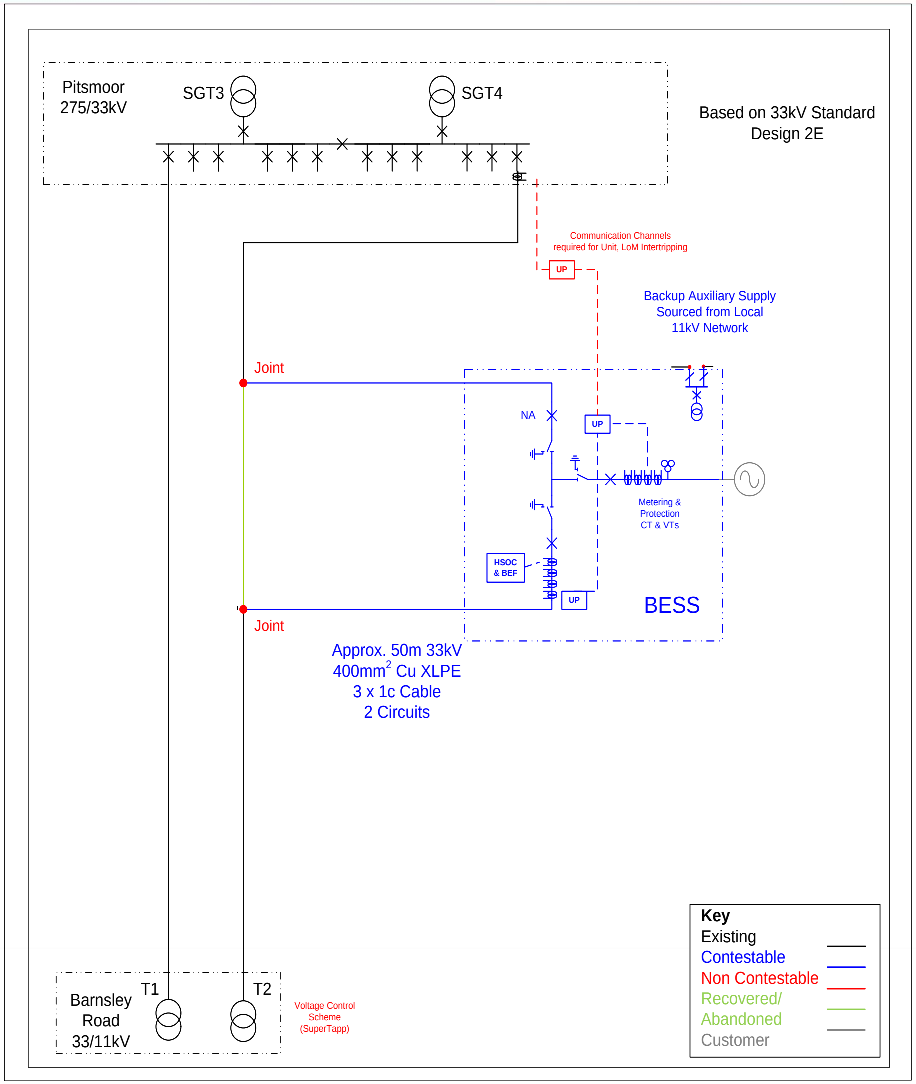
Worked scheme

- Request received for 60MW BESS installation.
- Providing EFR service – sub 1 second response.
- Non Firm connection requested.

Worked scheme – Network diagram



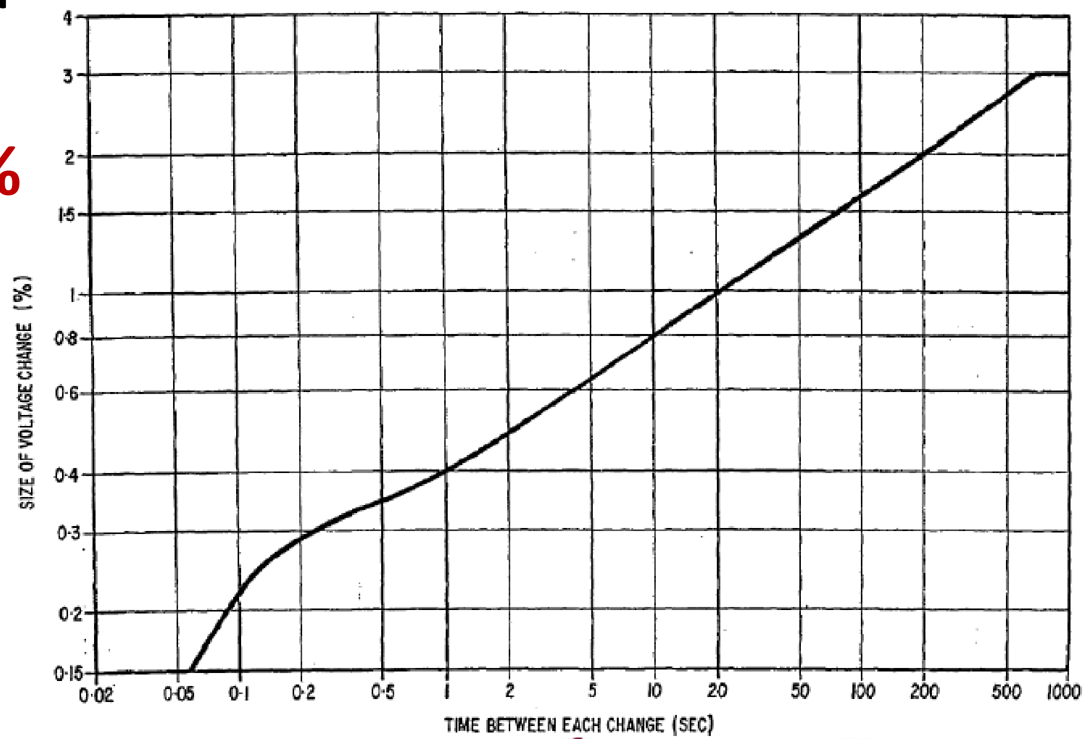
Worked scheme – Proposed SLD



Worked scheme – Voltage impact

- Engineering Recommendation P28 – Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment.

STEP VOLTAGE < 3%



Worked scheme – ER P28

- Network Intact – 30MW BESS (60MW Swing)
    - Acceptable <3% swing

- Minimum Plant – 10MW BESS (20MW Swing)
    - Acceptable < 3% swing

Connection criteria

- Thermal impact – Capability of circuit reduced scheme size.
- System fault level impact – Enhanced switchgear assessment.
- Voltage impact – Reduction under minimum plant conditions.

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Distributed Storage & Solar Study (DS^3)

Paris Hadjiodysseos
Design Engineer

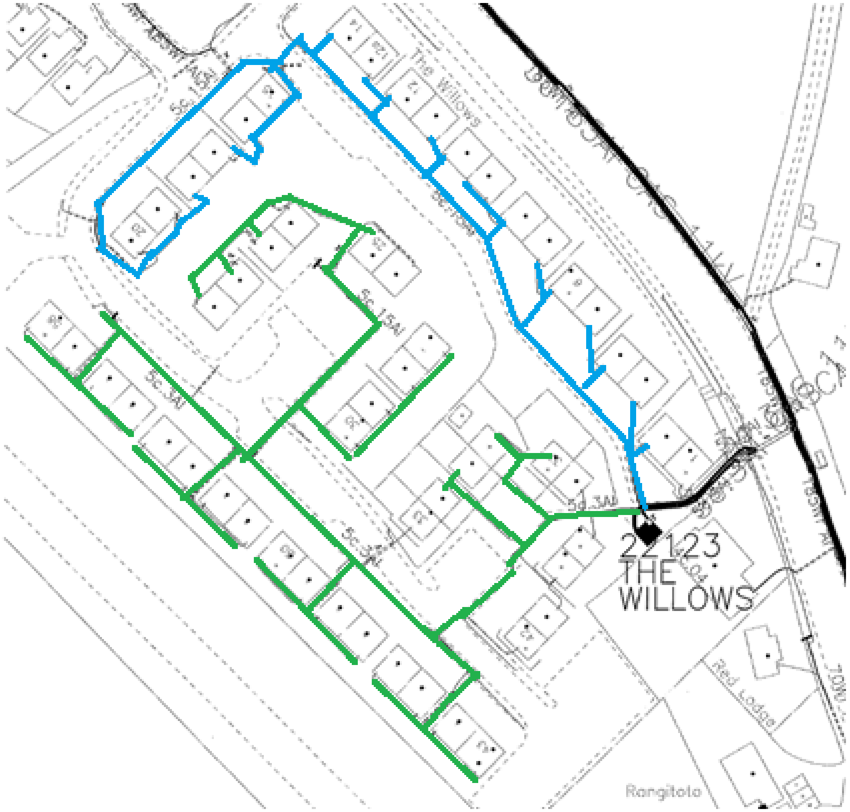
LV Generation application process (G83)

- Small-scale generation to a single premise
  - < 16A or 3.68kW per phase
  - Notify within 28days of commissioning

- Small-scale to multiple premises
  - < 16A or 3.68kW per phase
  - Apply for approval before connection

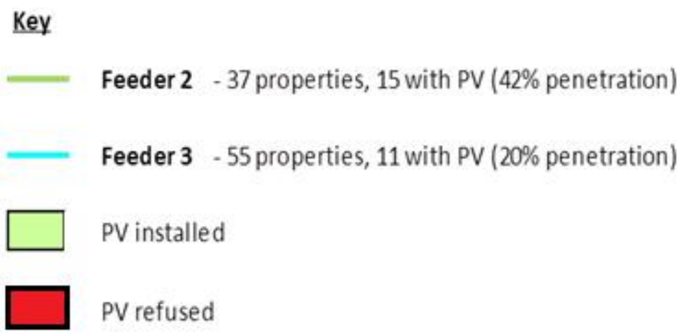
Assessment of multiple premises

- Declared Voltage limits: 230V +10/-6%
  - Load: 216V
  - Generation: 253V



- Worst case
  - Max generation and minimum load

2015 – Oxspring, Barnsley



- 2.7kW - 3.68kW
- Connected 27

2016 – Oxspring, Barnsley

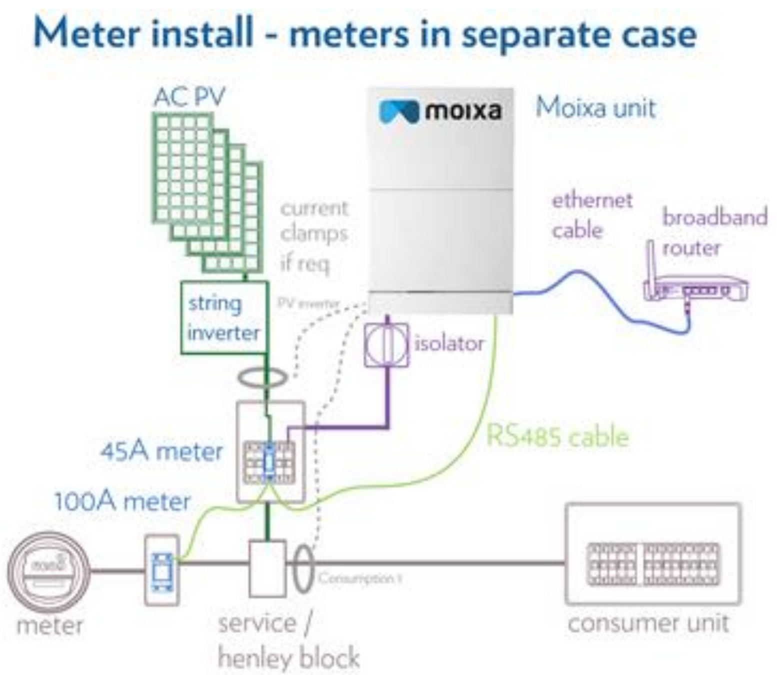
Key

- **Feeder 2** - 37 properties, 15 with PV (42% penetration)
- **Feeder 3** - 55 properties, 11 with PV (20% penetration)
- PV installed
- PV refused

- Install 26 batteries in all the houses with PV (or more)
- 14 additional batteries in the remaining houses

DS^3

- A community energy project involving Northern Powergrid, Gen Community Ventures and Moixa
- Part of Barnsley Council's Anti Poverty Action Plan 2015-18
- Focuses on social housing
- The partners' aims are to reduce householders' energy costs / provide opportunity for income from grid services



- 430w output inverter
- 2-3kWh Battery (up to 7hrs worth)
- DC Circuit lighting

What's in it for Northern Powergrid?

- Regen SW: 2030 70-80% of rooftop PV installed with storage
- Develop an understanding of the impact PV/storage combination on network design
- Understanding the network benefits (if any) of storage behind the meter
- Supportive of Barnsley Council's Anti-Poverty Action Plan

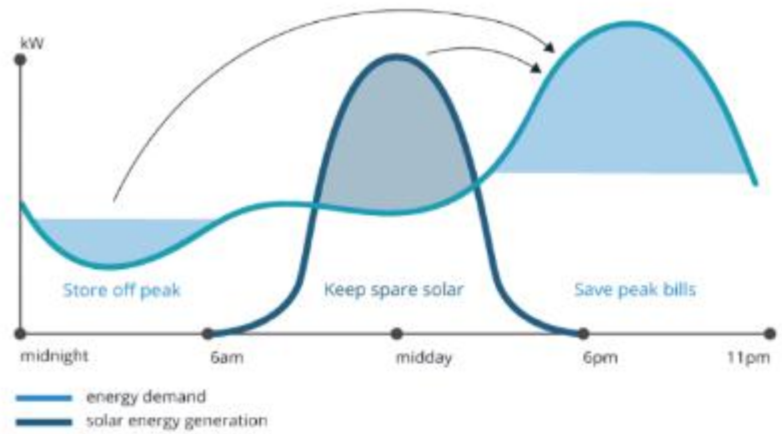
What are the costs?

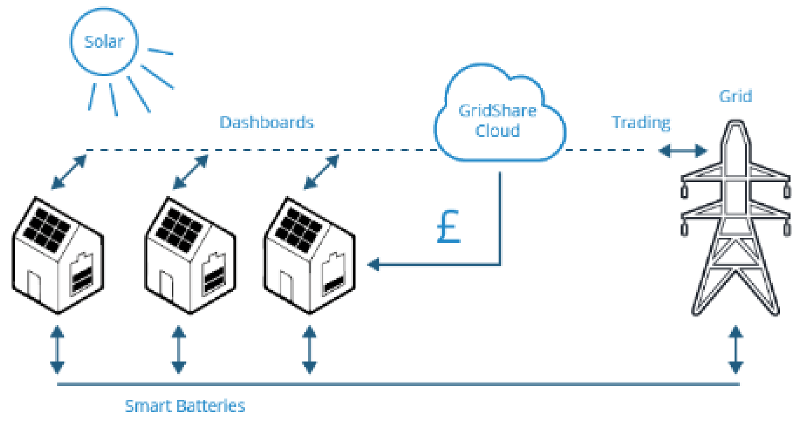
- £250k financial contribution:
  - Purchase & install 40x batteries
  - Substation monitoring equipment
  - Data analysis and network modelling

How the battery works

- Store excess solar energy as well as Economy 7

- Aggregate batteries to create 'virtual power station' & release power to the network





Potential DNO learning

- How a battery can affect the peak output of a PV installation & reduce peak load consumption
- What battery penetration is needed to make a difference to PV constraint & peak load
- Whether a de-rating factor would be appropriate for PV installations that have a battery
- Whether different design parameters would be appropriate to new housing estates with batteries
- Gaining an understanding of the Moixa Cloud aggregation platform and how a DNO can interact with it to dynamically manage constraints

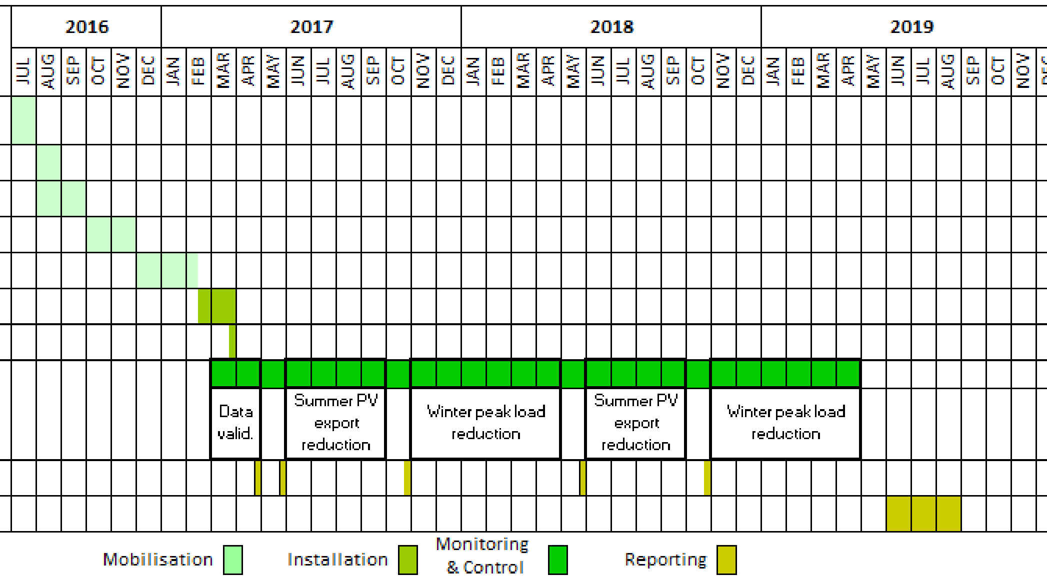
Analysis

- Impact of batteries on network current flows and voltage:
  - Trial 1: Default algorithm to maximise the benefit of storage for tenant
  - Trial 2: Alter algorithm to maximise DNO benefit
- Is there any change if the batteries are providing other grid services
- How does this compare to the benefits of DNO owned storage on the network?
- Recommendations for designers:
  - Can designers accept more PV if there is aggregator controlled storage behind the meter?
  - Can designers design to a lower ADMD if storage is installed in premises?

High level project plan

Project plan for Energise Barnsley - Distributed energy storage and services

	High-level Plan	
1	Agreement to proceed in principle / internal authorisation	July
2	Collaboration Agreement	August
3	Agree project outcomes, data requirements, plan, etc	August
4	Customer Engagement Plan / Data Protection Strategy	Oct - Nov
5	Engage stakeholders & tenants and confirm opt in	Dec - Jan
6	MASLOW Battery installation (40 properties)	Feb - Mar
7	Install Network Monitoring (1 substation)	Mar
8	Data collection & Analysis Specific Trial objectives	Apr
9	Interim reports	Various
10	Final report / dissemination event	Aug-19



Project partners and contractors

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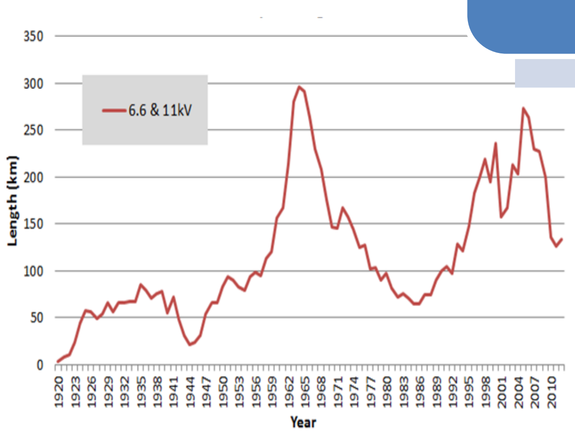
Smart Grid Evolution

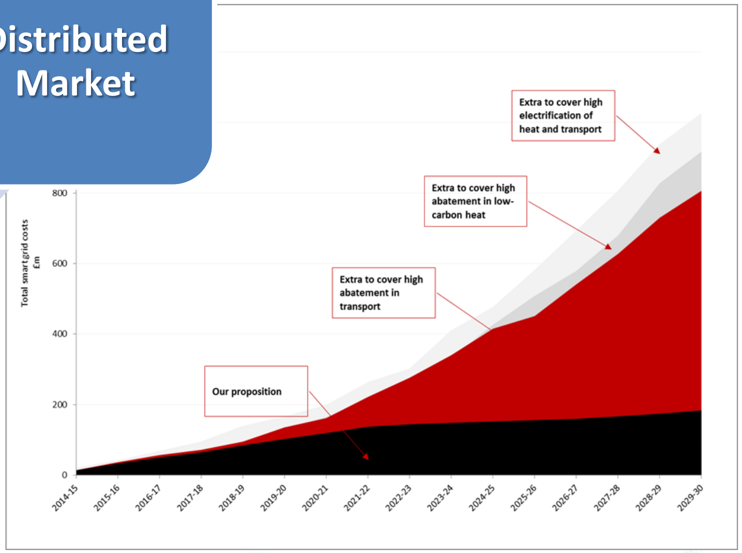
Mark Nicholson
Head of Smart Grid Implementation

Change is occurring but the pathway to a smarter grid is different for each operator

Where are we heading?

Fit'n'Forget → **Active Management** → **Distributed Market**





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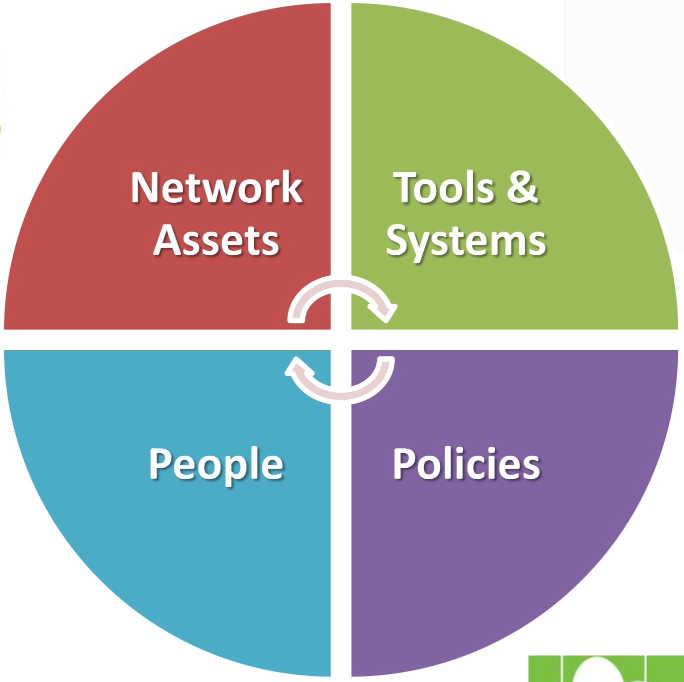
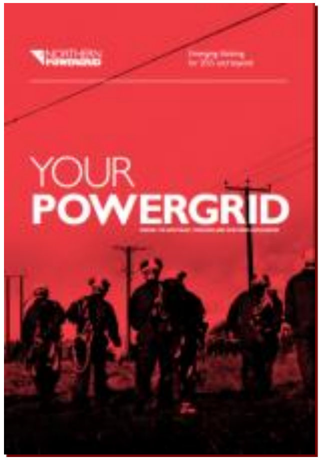
Strategy in ED1 submission then built on through learning

LCN Fund
Low Carbon Networks

Low carbon LONDON
Energising change

WESTERN POWER DISTRIBUTION
FALCON





Customer-Led Network Revolution

electricity north west
Customer Load Active System Services
CLASS

NORTHERN POWERGRID

Network assets – biggest technical change since 70s

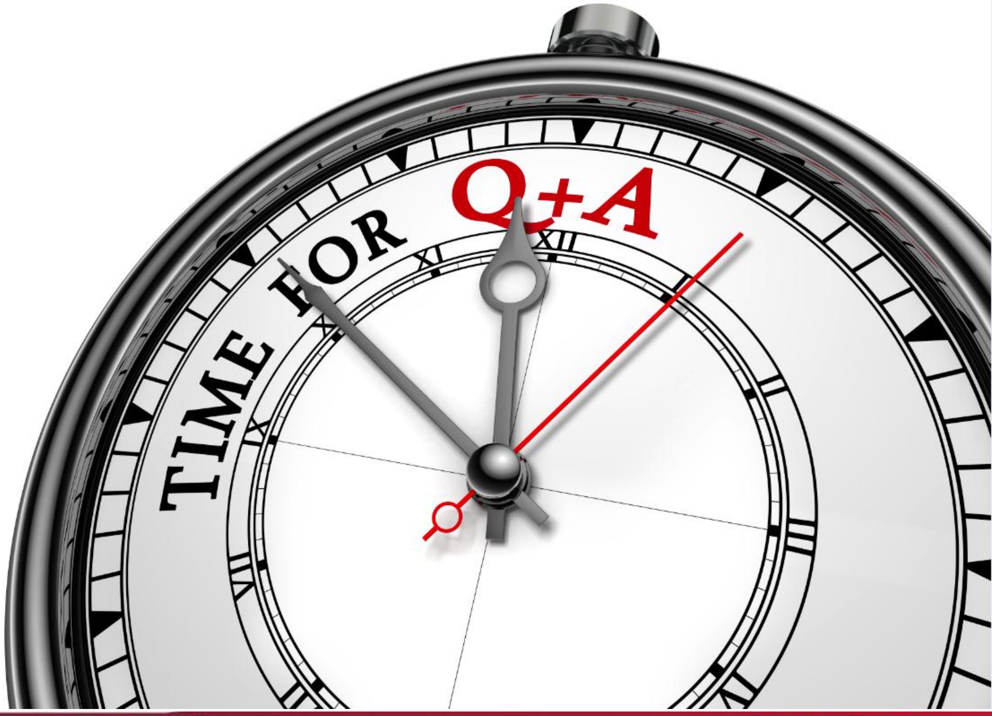
Area	As-is	To be
Telecoms (primary)	1200 baud, 8bit & 16bit legacy protocols, limited redundancy	IP based network with additional resilience across 800+ sites
Telecoms (secondary)	Control operations limited Fault location data only	RF mesh operating over 7000+ sites
Primary RTUs	Varying levels of reliability	Upgrade & replace RTUs across 500+ sites Platform for local control & IP capable
Voltage control and monitoring	Limited control of tap changer Commenced voltage reduction	Functionality for ANM & reactive services Improved visibility & alternative settings
ANM systems	Non standard systems for single & multiple generators	Standardised approach Build on advanced ANM from CLNR
Distribution monitoring	Limited visibility downstream of HV source breaker	Pole mounted recloser Retrofitting of GM distribution subs

Policies – more transparent & responsive

Area	As-is	To-be
Design policy	Principle based, updated every few years	Keep principle based but incremental development with additional transparency New policies built on industry good practice & innovation project output - Revisions to HV & LV design policies - ANM - Updates to cable & overhead line ratings policies plus new transformer ratings policy - Network monitoring policy - Use of I&C DSR
Application guidance	Little exists	Case study based developed on first few applications with end users - HV & LV regulators - Applying LDC at substations - Generators operating in PV mode - Constraint management – more standardisation - Use of fault level monitors - Use of RTTR - Use of distribution OLTC

Roundtable exercise

- What are the emerging technologies and what new challenges will they bring?
- 10 minutes please…
- Feedback to the group



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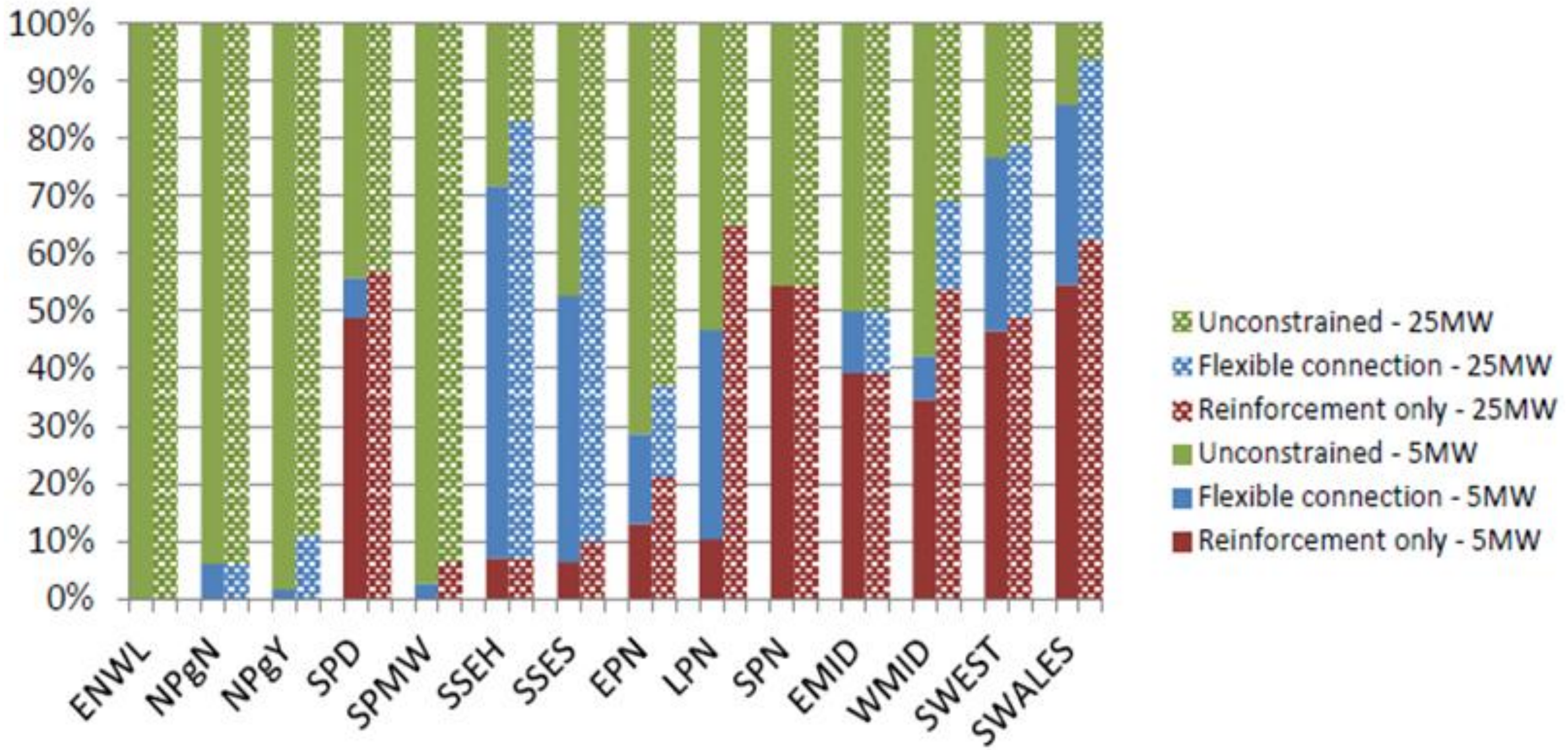
Addressing Network Constraints

Roundtable Discussion

A headline from Ofgems update document



Levels of 'significant' constraints reported in May 2016

Our area is predominantly unconstrained

- The bulk of our substations have spare capacity
  - 2/3 of higher voltage circuits have material capacity for new generators
  - 91% of larger substations can accept 25MW of new generators
- In four locations generators have accepted more flexible and innovative offers instead of paying for upstream reinforcement
  - Blyth – constraint on NGET equipment
  - Seal Sands – constraint on our equipment
  - Driffield – constraint on our equipment (at Driffield and Beverley)
  - Hull East to Roos – single customer constraint on the circuit
- In the 2015/16, flexible connection of 130MW of EHV generation has saved £4m in connection costs