nationalgrid

Langage- Landulph incident 22/05/16, impacts upon Loss of Mains Protection & next steps.

13th September, 2016 – ENFG

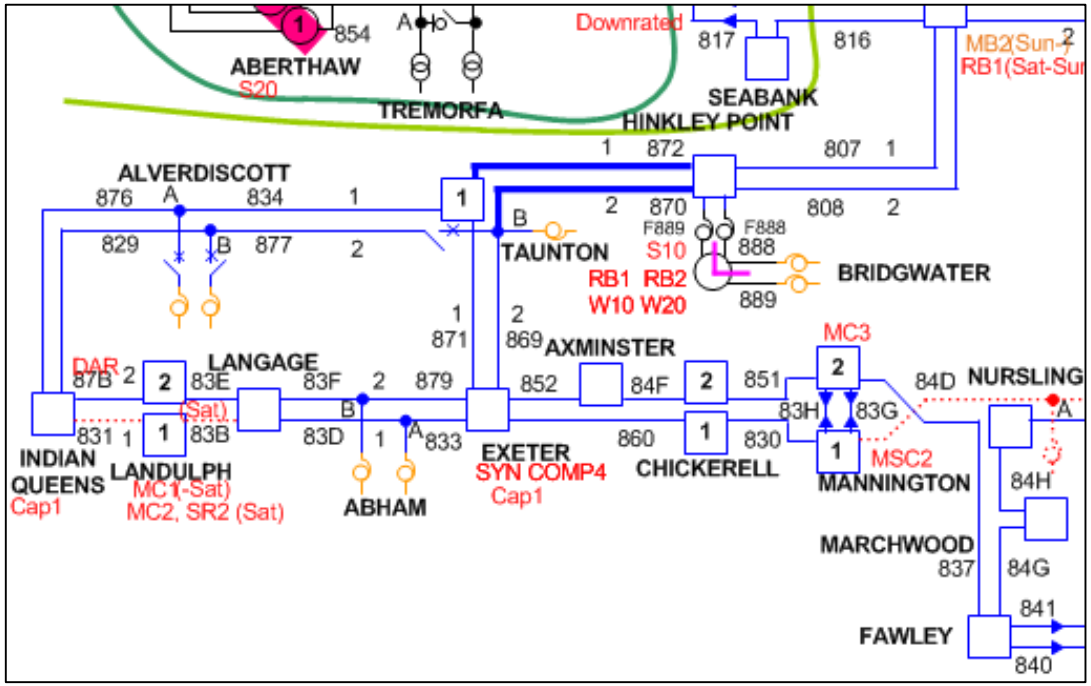
Graham Stein, National Grid (SO)

nationalgrid

Contents

- 22/05/16-What happened
- Outcome of joint Western Power Distribution (WPD) and National Grid investigation.
- Interim conclusions.
- Implications for existing reviews of Loss Of Mains protection
  - Requirement for a focused short term solution to facilitate continued DG connection
- Proposed next steps.

22/05/16- What Happened (1).



- At 11.12 am on the 22nd May 2016 the Landulph- Langage circuit 2 opened at both ends as the result of a single phase- ground fault.
- Coincident with the above circuit trip, a demand surge of some 400MW was observed at the Grid Supply Point (GSP) interfaces concentrated in the South West area shown above.

22/05/16- What Happened (2).

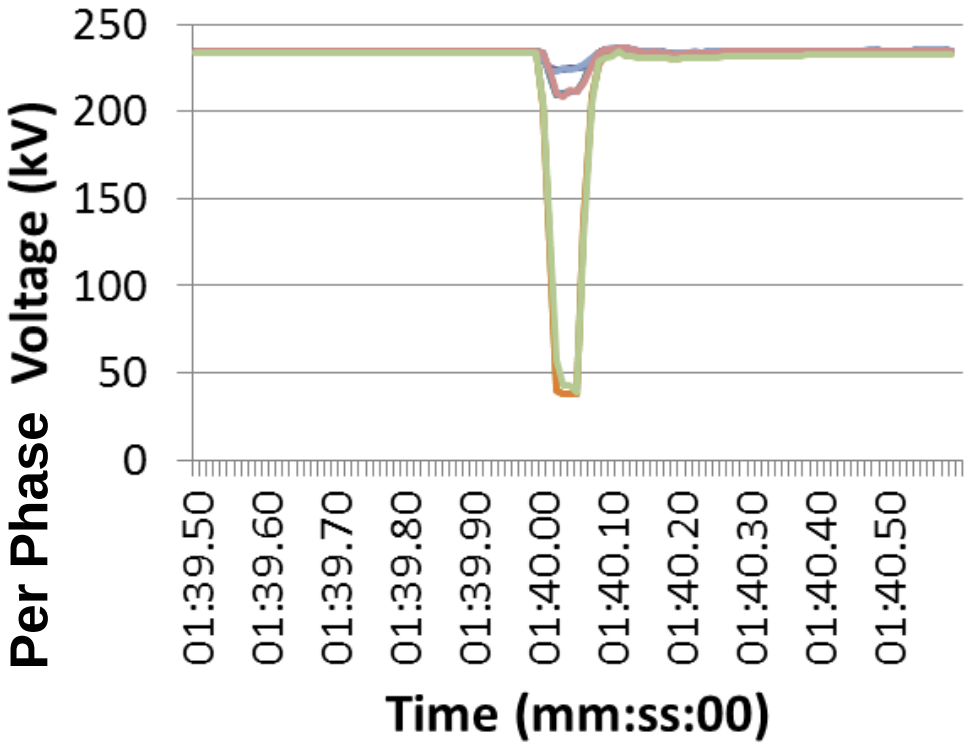
Sequence of events.

- Prior to the fault as per the previous slide, the network was largely intact- other than the planned and agreed outage of the Indian Queens- Landulph 400kV no.1 circuit.
- At the time, transmission generation in the area comprised Marchwood CCGT and Hinkley Point B Nuclear Power Station.
- Total Transmission System Demand prior to the loss was some 27200MW.
- The maximum loss of power infeed at the time on the transmission system was 800MW

22/05/16- What Happened (3).

Sequence of Events continued.

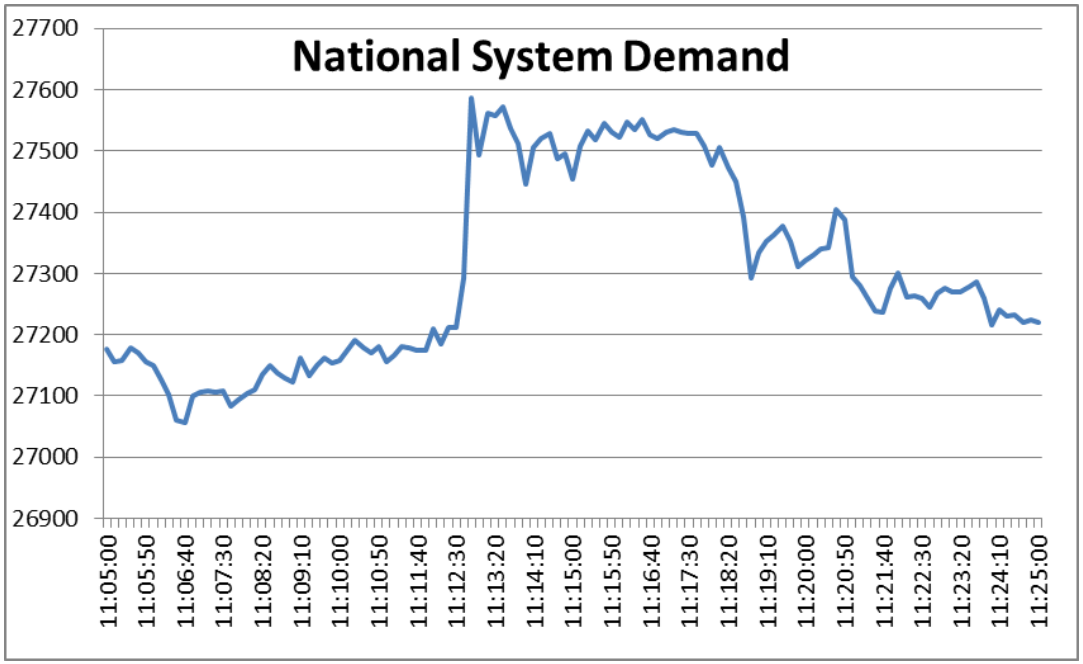
- At 11.12 the Langage-Landulph 400kV circuit 2 opened. This was preceded by a single phase voltage dip upon the transmission system during the fault as illustrated below as observed at Langage 400kV (0.66p.u. voltage dip in RMS)



22/05/16- What Happened (4).

Sequence of events continued.

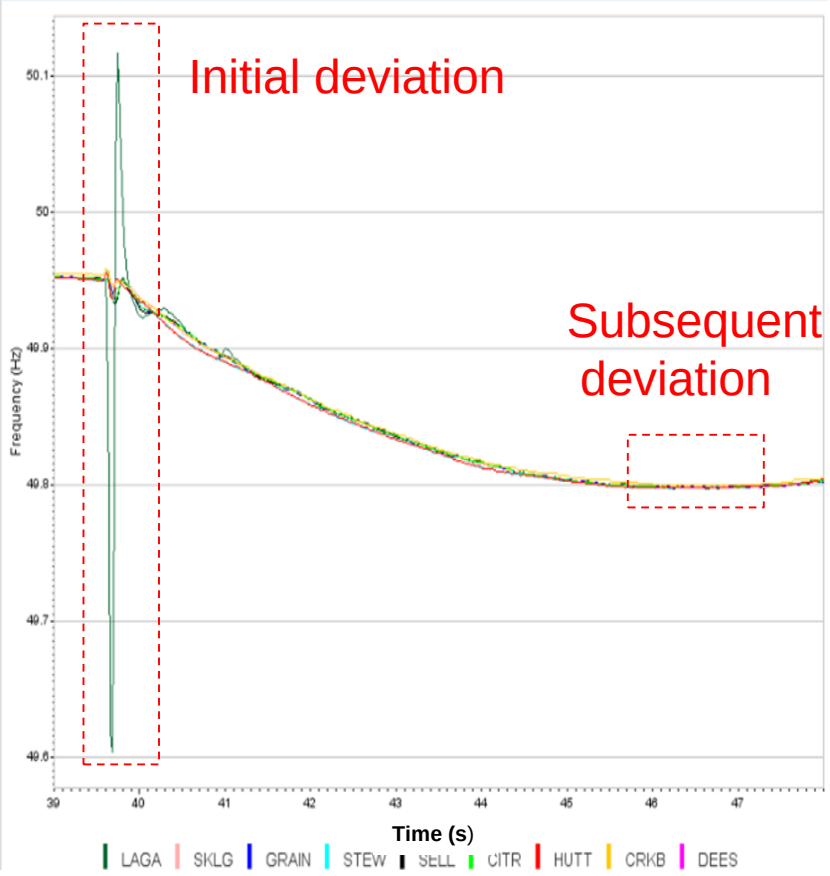
- The circuit fault was cleared by main protection operation within 120ms.
- No transmission connected generation was lost as a result of the fault.
- Following the fault clearance, the National demand was seen to surge as shown below by some 400MW.



22/05/16- What Happened (4).

Sequence of events continued.

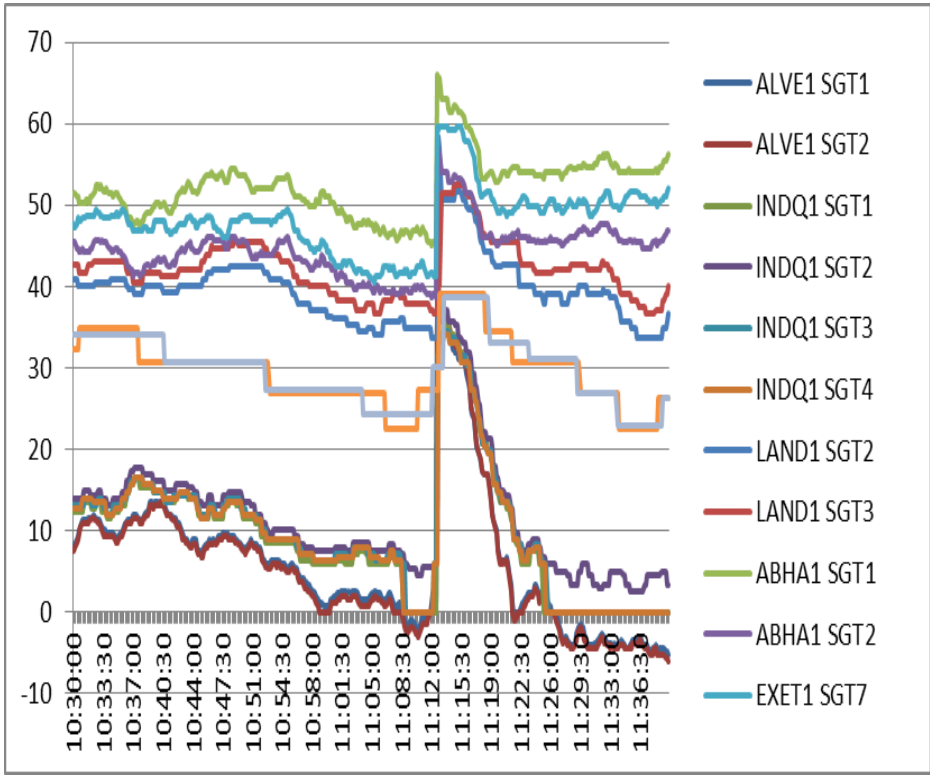
- As a consequence of the demand surge, a Low Frequency event occurred. This saw a reduction in system frequency from 49.96Hz down to 49.79Hz (below the operational limit of 49.8Hz). This triggered activation of frequency response to restore system frequency within operational limits.
- There was an initial frequency deviation lasted for some 3 seconds, a subsequent deviation of some 1minute 30secs.
- System frequency, local (green) and remote is shown to the right (1s .resolution):-
- Rate of Change of Frequency as measured by PMUs in the local area reached a maximum level of 0.046Hz/s (averaged over 500ms)



22/05/16- What Happened (5).

Sequence of events- .

- DAR operated at 11.13am to re-close the Langage-Landulph circuit 2.
- GSP demand in the South West as recorded over the period confirms that the Transmission system- generation interface transitioned from a lightly loaded state pre-fault to a total Supergrid Transformer (SGT) increase of some 400MW across the period
- Following this fault the return to pre-disturbance levels occurred within 6 to 10minutes.
- WPD reported that some of their Distributed Generator (DG) customers had been affected by the 400kV circuit trip.



Outcome of the Joint WPD & NGET Investigation (1)

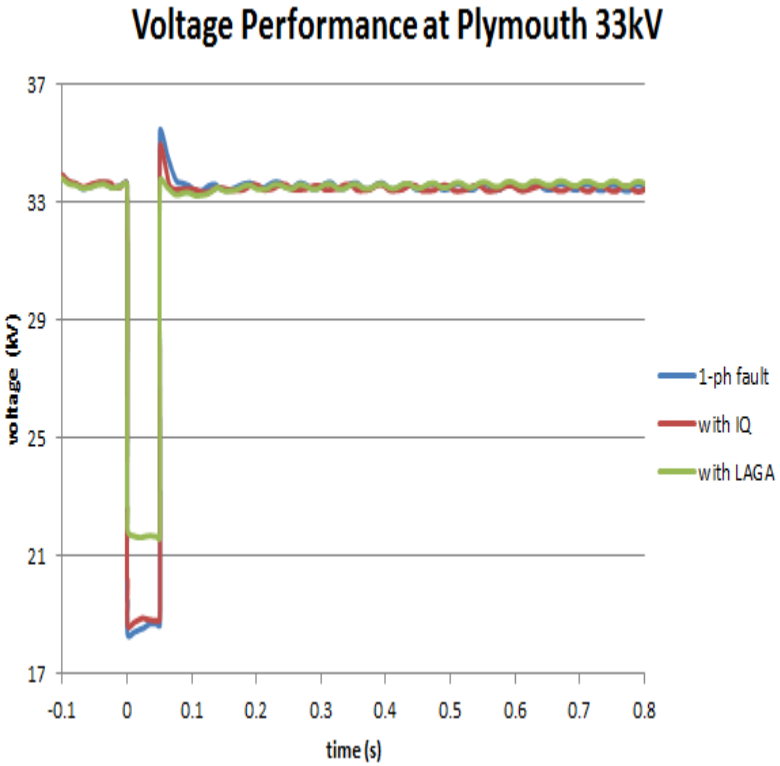
nationalgrid

- WPD have confirmed that there was some 21 individual installations (where they had visibility) for which Loss Of Mains protection had operated and that these totaled some 40MW of overall solar PV generation capacity
- 1 DG site had no G59 relay operation occur. No RoCoF or UV relays operated.
- The majority of DG sites had Vector Shift protection enabled, WPD have noted that some 66.8% of Small Power Stations > 5MW use Vector Shift protections. The ratio is higher at lower levels of projects
- Vector Shift (VS) protection is set at 6 degrees
- Subsequent site visits confirmed 4 VS operation (1 further subsequently identified). During the fault, VS activated, tripping in 60ms typically.
- From relay data at one site identified close to the fault location the vector shift was recorded as 12.8 degrees. However a genuine local loss of mains event had been recorded on this same relay over recent months with an over 13 degree vector shift. The maximum vector shift this relay had recently recorded was some 47 degrees.
- Some limited experience of some Vector Shift relays blocking operation for under- voltage. These were set where available triggering at 0.1 p.u. voltage to inhibit VS.

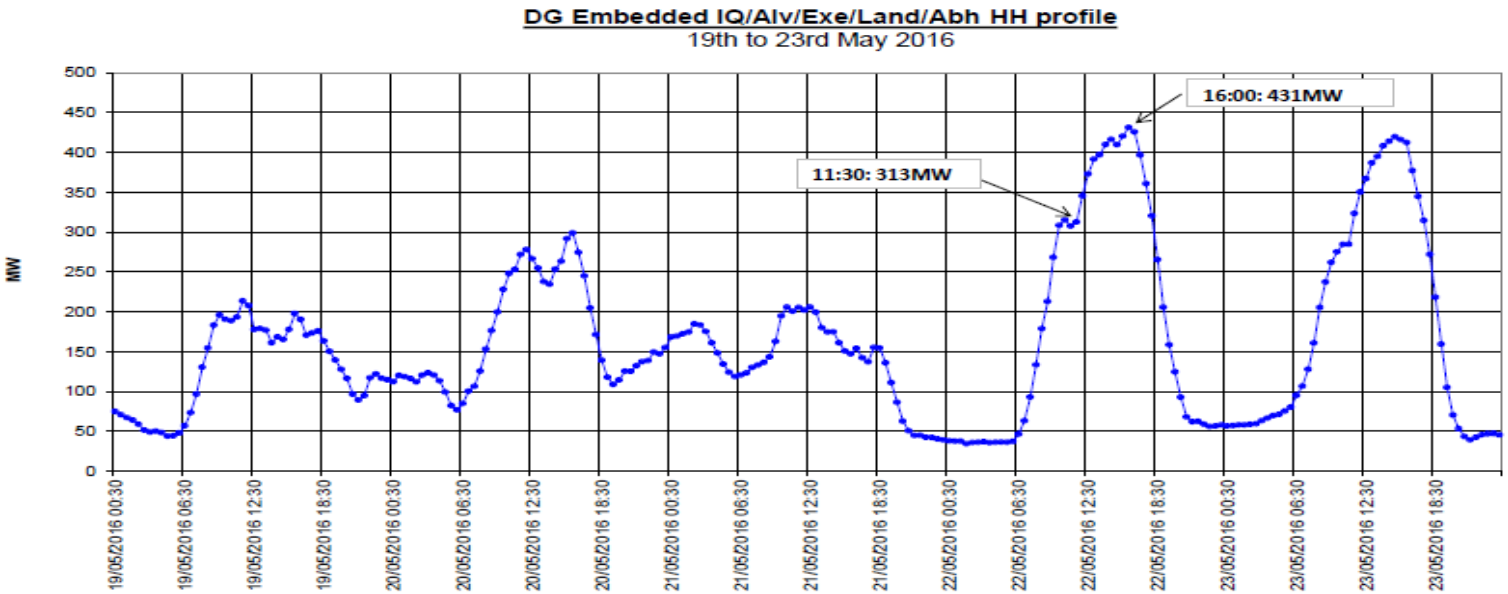
Outcome of the Joint WPD & NGET Investigation (2)

nationalgrid

- National Grid has studied both Voltage Dip and Vector shift at transmission level with good agreement with actual events, and from this simulated the Distribution system voltage dip during the fault. Plymouth 33kV is shown below for illustration (includes sensitivity of the effect of additional transmission generation running).
- No voltage dips below 0.5p.u. have been observed down to 33kV (the limits of our models) as such we do not believe under voltage blocking on VS relays operated.
- During the fault, a Vector shift of up to 35 degrees is observed, as would be expected for any system disturbance. Following fault clearance however, no material vector shift is observable



Outcome of the Joint WPD & NGET Investigation (3)



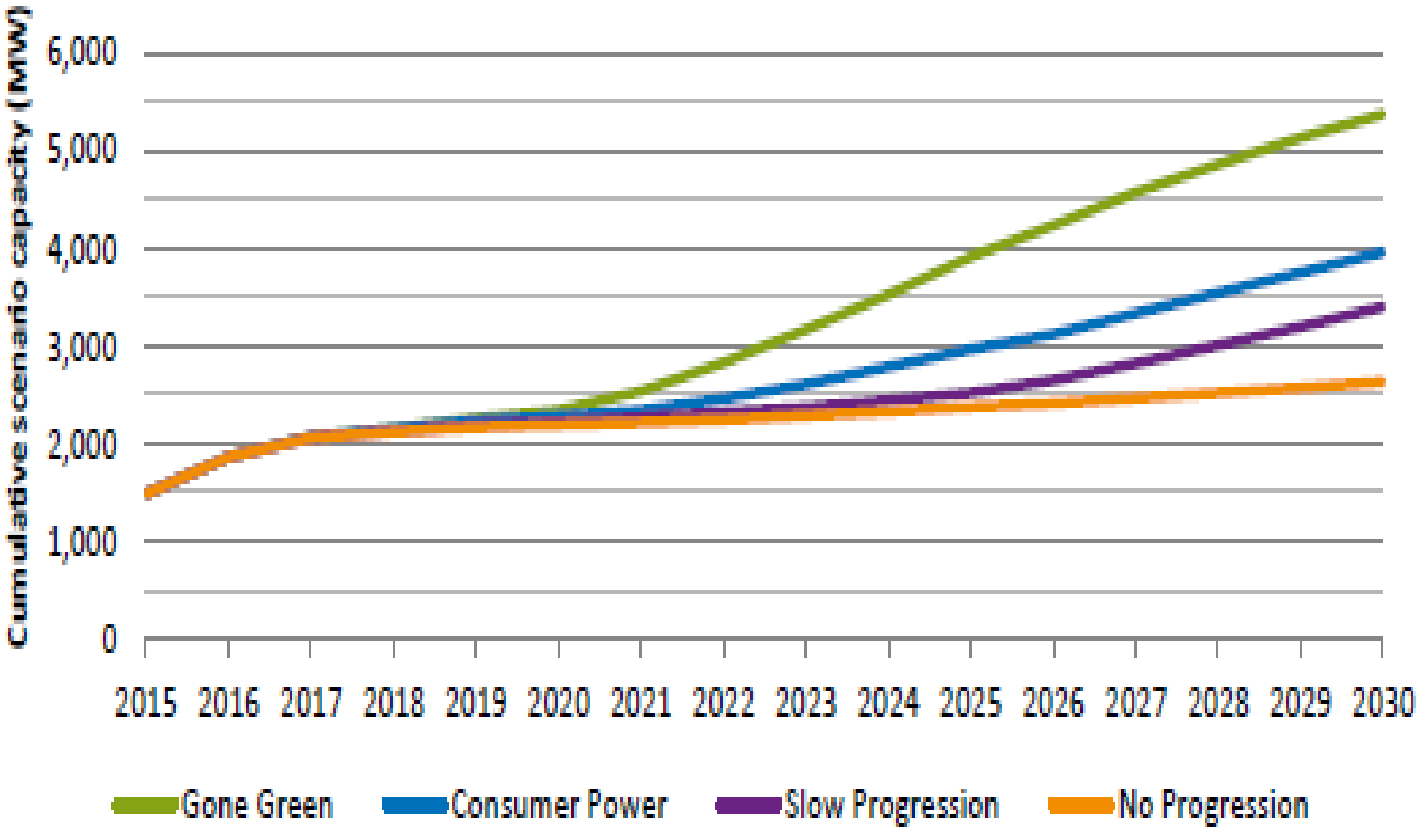
- WPD have confirmed that around the time of the incident settlement, half hourly metering can attribute some 313MW of distributed generation at the time (>100kW sites). Being an averaged half hour value and accounting for the 6-10minute timeframe of disruption, this value aligns with the loss observed.
- WPD confirm that this accounts for some 50% of the total available generation capacity present within the South West network. ***As such the maximum credible loss for a solar maximum (c. 2pm in summer), high wind day could have been some 800MW***.

nationalgrid

Interim Conclusions.

- Both WPD and National Grid are able to confirm that ***Distribution Generation disconnecting in response to the Transmission System Fault described on 22/05/16 lead to the frequency event observed.***
- WPD and National Grid can ***confidently rule-out RoCoF*** relay operation during the event based on an absence of any supporting evidence for that.
- WPD and National Grid ***cannot confidently dismiss the probability that Vector Shift protections triggered under this fault.***
- A transmission fault associated with generation in the area (for example Langage 902MW scale loss) would have an equivalent distribution system effect to that described above- and could now be compounded by DG loss totalling up to 800MW at present. The loss of DG alone could be equivalent or greater than the largest transmission loss at times on the network. ***Additional DG connection subject to this vulnerability would drive additional operational cost and risk which at present is not visible to the Network Operators in real time, and so risks delaying /impeding new connections without a short term solution.***

Levels of DG growth estimated.



DG capacity Growth 2015-2030 within the south west region-

Courtesy of the WPD Network Strategy report “Shaping Subtransmission to 2030”

http://www.westernpower.co.uk/About-us/Our-Business/Our-network/Strategic-network-investment.aspx

nationalgrid

Proposed Next steps

- The issues identified in Vector Shift protection risk of mal-operation are consistent with the findings of the ETR 139 work as part of the GC079 working on Loss Of Mains Protection, and the findings on Voltage Dip consistent with that in SOF. ***The vulnerability to Vector Shift protection is the key short term issue that needs to be addressed***.
  - WPD and National Grid are initiating further work with The University of Strathclyde to model Vector Shift relays in more detail which will input into longer term work towards enduring Loss Of mains Protection solutions under the GC0079 workgroup.
- However in order not to impede the levels of Solar growth anticipated over this and next year in the South West, ***a Short term solution is essential ahead of DG commissioning***
  - Noting that under D.P.C.7.4.3.6. it is possible to vary G59 and G83 settings for stability reasons, and noting the evidence of this incident, National Grid and WPD considering the option of the implementation ahead of longer term GC079 actions of implement RoCoF based protections based on the GC0079 >5MW recommendation of 1Hz/s on new commissioning non-synchronous DG projects smaller than 5MW also, in order that this issue does not impact or delay these connections.
- ***Consideration of this approach and our interpretation of D.P.C.7.4.3.6 would be welcomed from the GC0079 workgroup as a matter of urgency***, as would any wider application of these short term arrangements, ahead of taking action.