P2/6 workshop

14th September 2007

CBDs & HILP events

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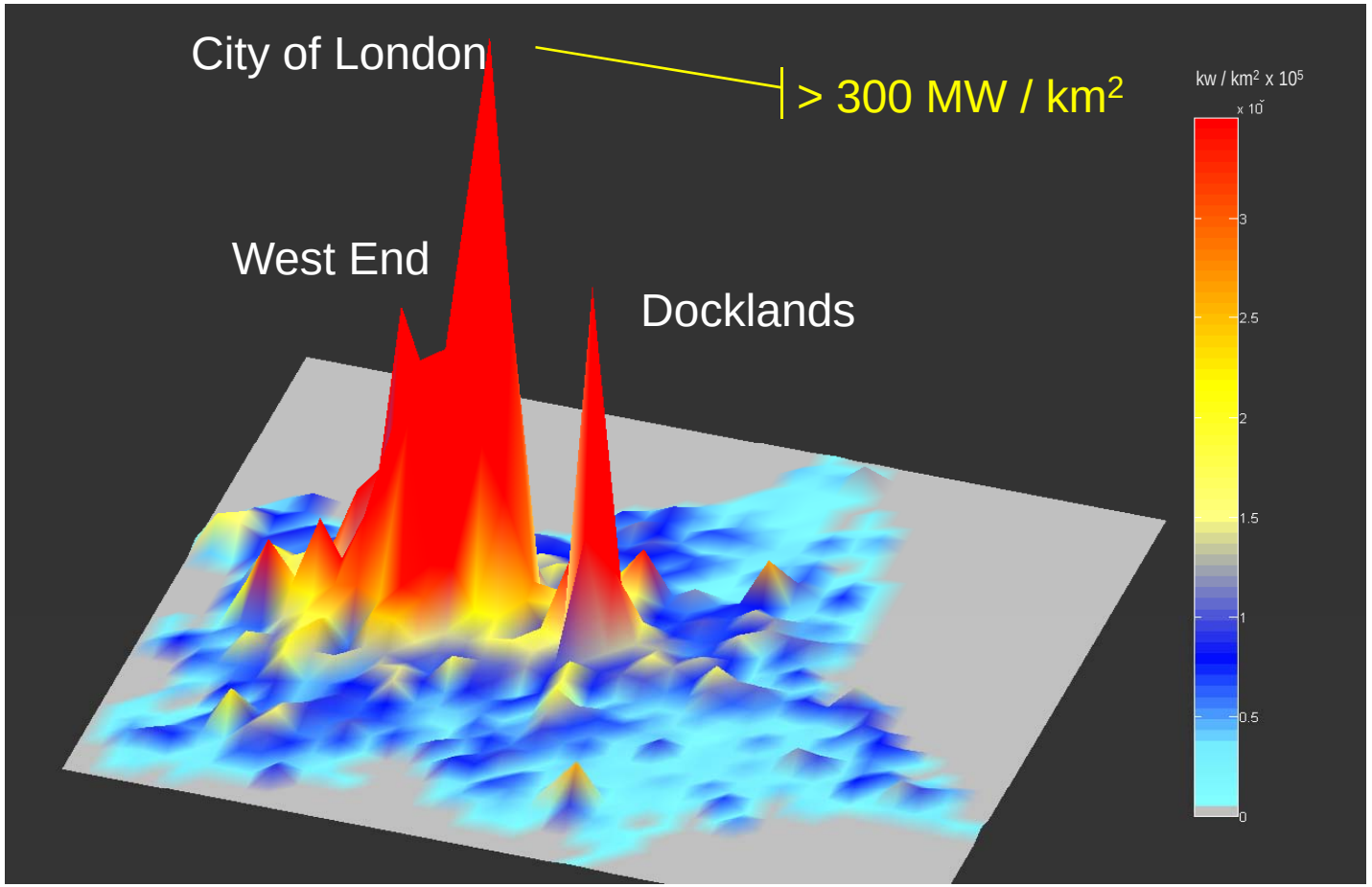
The anatomy of a Central Business District （CBD）

The City of London

- $1,109bn foreign exchange turnover each day in London (32% global share)
- 40% of the global foreign equity market
- 70% of all eurobonds traded in London
- £3,450bn total funds under management in the UK in 2005
- £1,607bn pension fund assets under management (third largest in the world)
- $643bn daily turnover in ‘over the counter’ derivatives (43% of global share)
- 80% of the $8bn EU Emissions Trading Scheme
- 75% of Fortune 500 companies have London offices
- 255 foreign banks in London
- 610 foreign companies listed on the London Stock Exchange (LSE)

http://www.cityoflondon.gov.uk/Corporation/media_centre/keyfacts.htm

The electrical footprint of a CBD



The High Impact Low Probability Event （HILP）

High Impact

- Complete loss of major substation infeed
- Repair time duration - possibly running to weeks
- Commercial and societal impacts
- Large business losses (also impacting staff)
- Transport disruption (also affecting visitors, tourists etc.)
- Undermines credibility of the CBD on the international stage

Low Probability

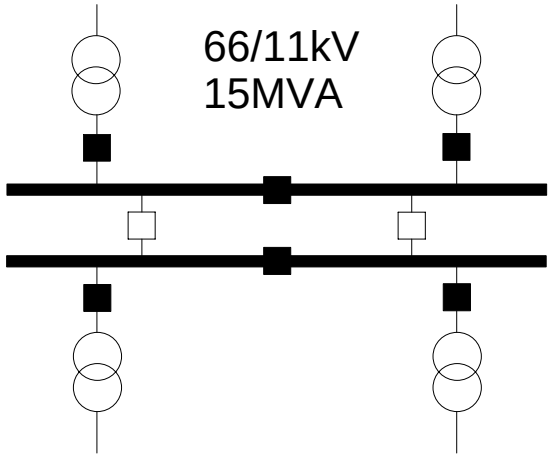
- Coincident fault outages
- Major electrical fault with collateral damage
- Damage to a multiple circuit route
- Extreme weather
- Flooding (including water main burst)
- Terrorism

London's central area networks

- Large capacity Main Substations
- Four or Three transformer configurations
- Auto-switching under transformer outage
- 11kV network in 'feeder groups'
- Limited or no 11kV interconnection between groups
- Consequently little support for N-2 outage at Main Substatio
- LV network meshed with interconnection between 11kV feeders
- Capability to maintain supplies under 11kV N-1 conditio
- This design has served London well historically
- But is it good enough for the City of London's CBD?

London's Main Substation configurations

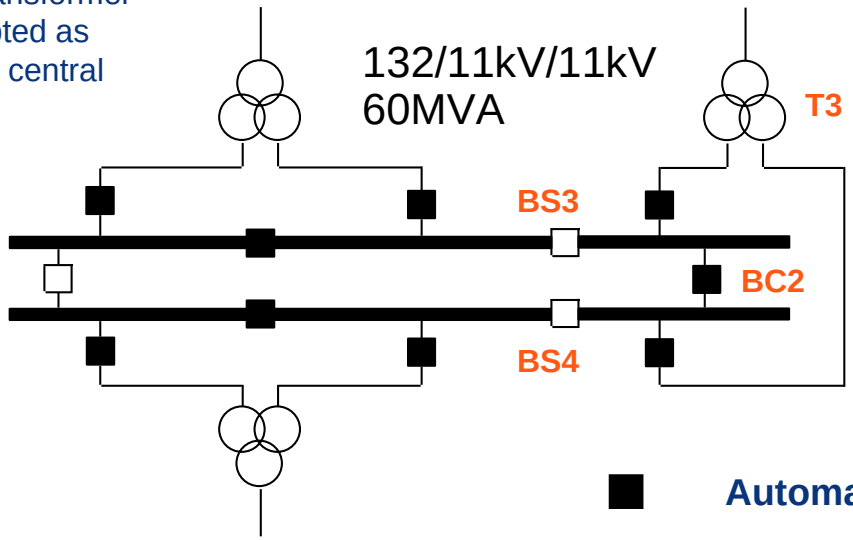
4 transformer design used prior to 3*60MVA arrangement.



Auto-switching

For loss of any transformer bus coupler closes putting three transformers in parallel.

3*60MVA transformer design adopted as standard for central area.



Auto-switching

For loss of transformer T3, bus coupler BC2 opens, and bus sections BS3 & BS4 close.

■ **Automatic switch in closed position**

□ **Automatic switch in open position**

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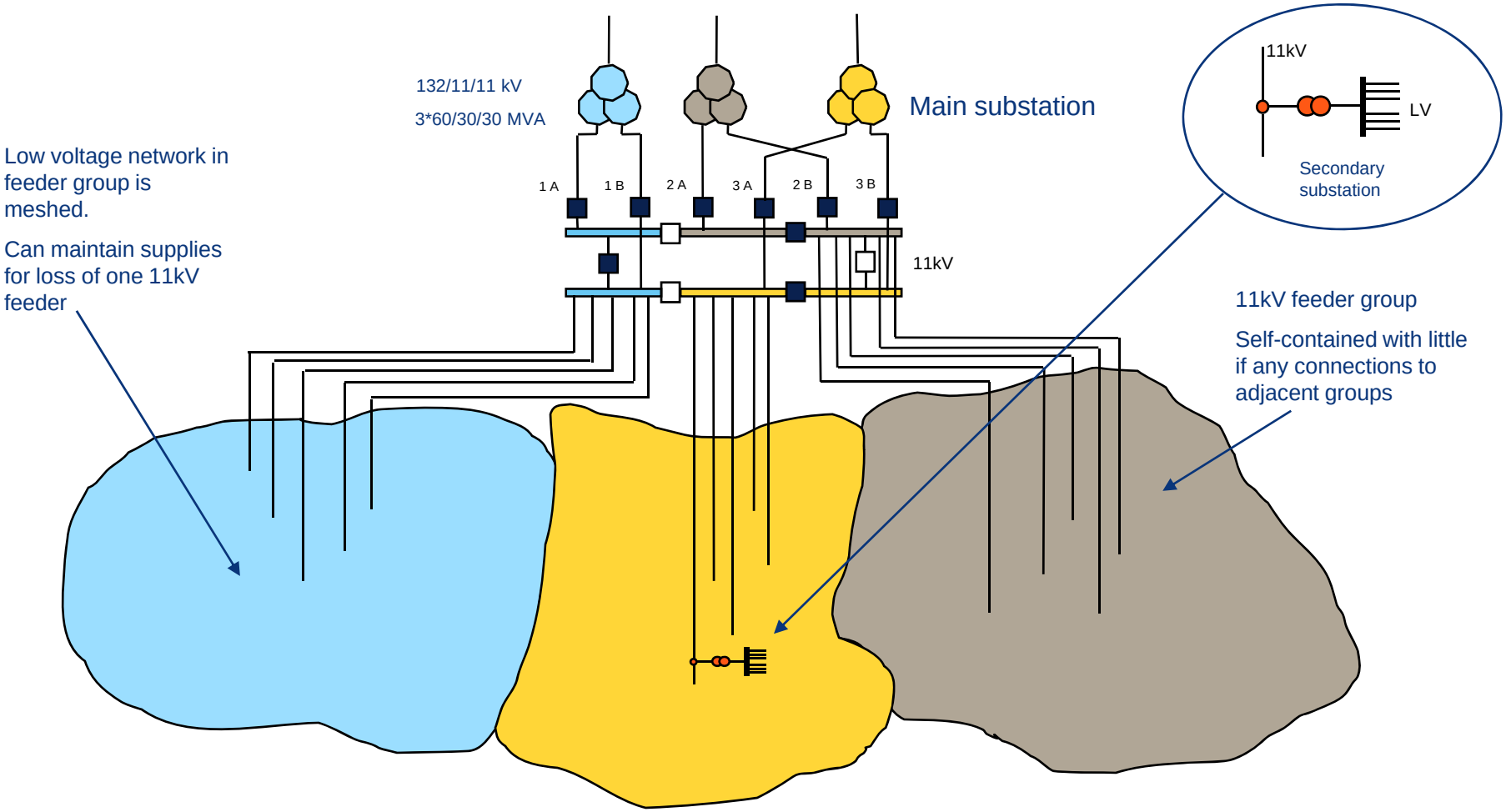
London's 11kV Feeder Group design



Representation of 11kV network groups

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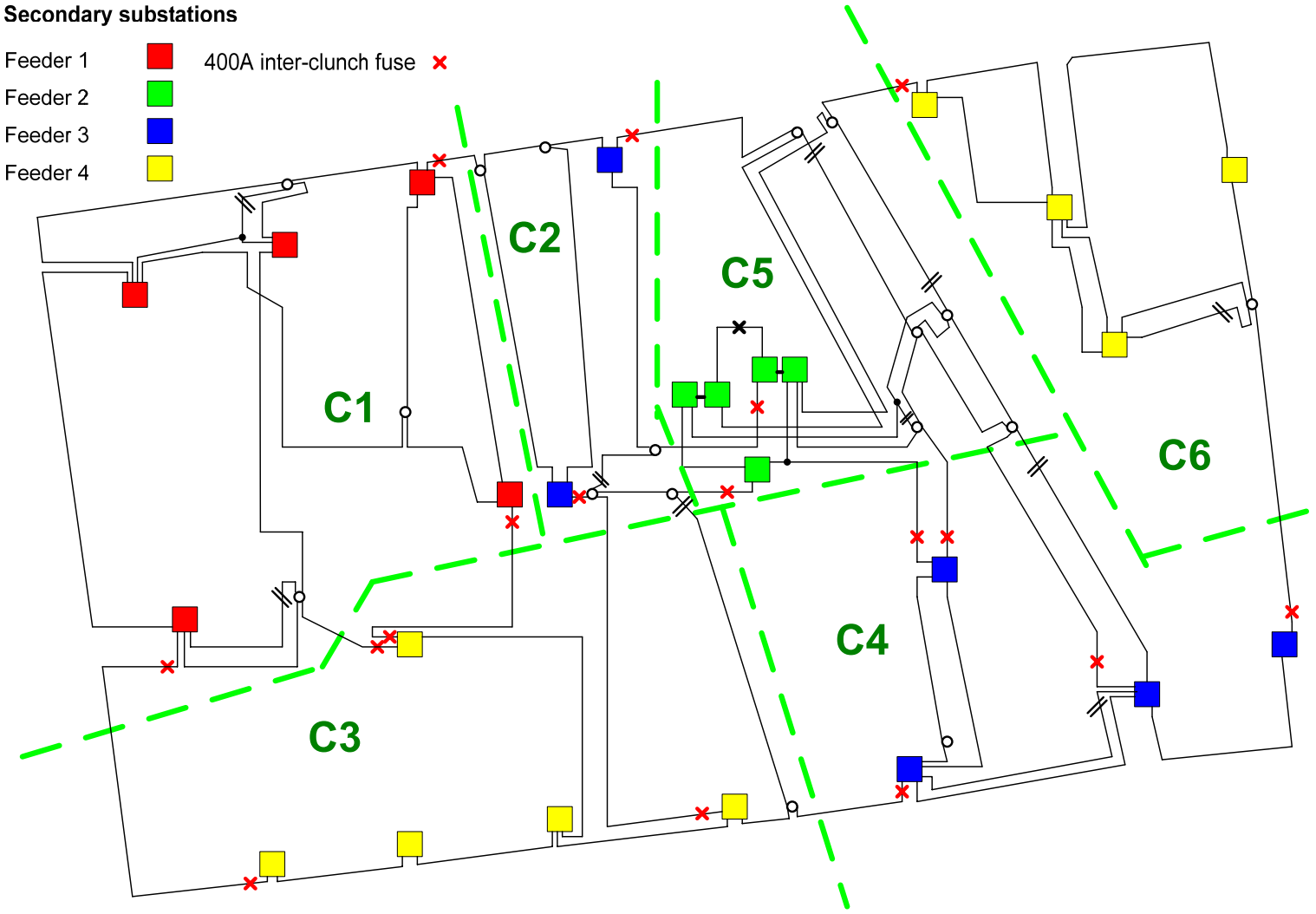
LV interconnection



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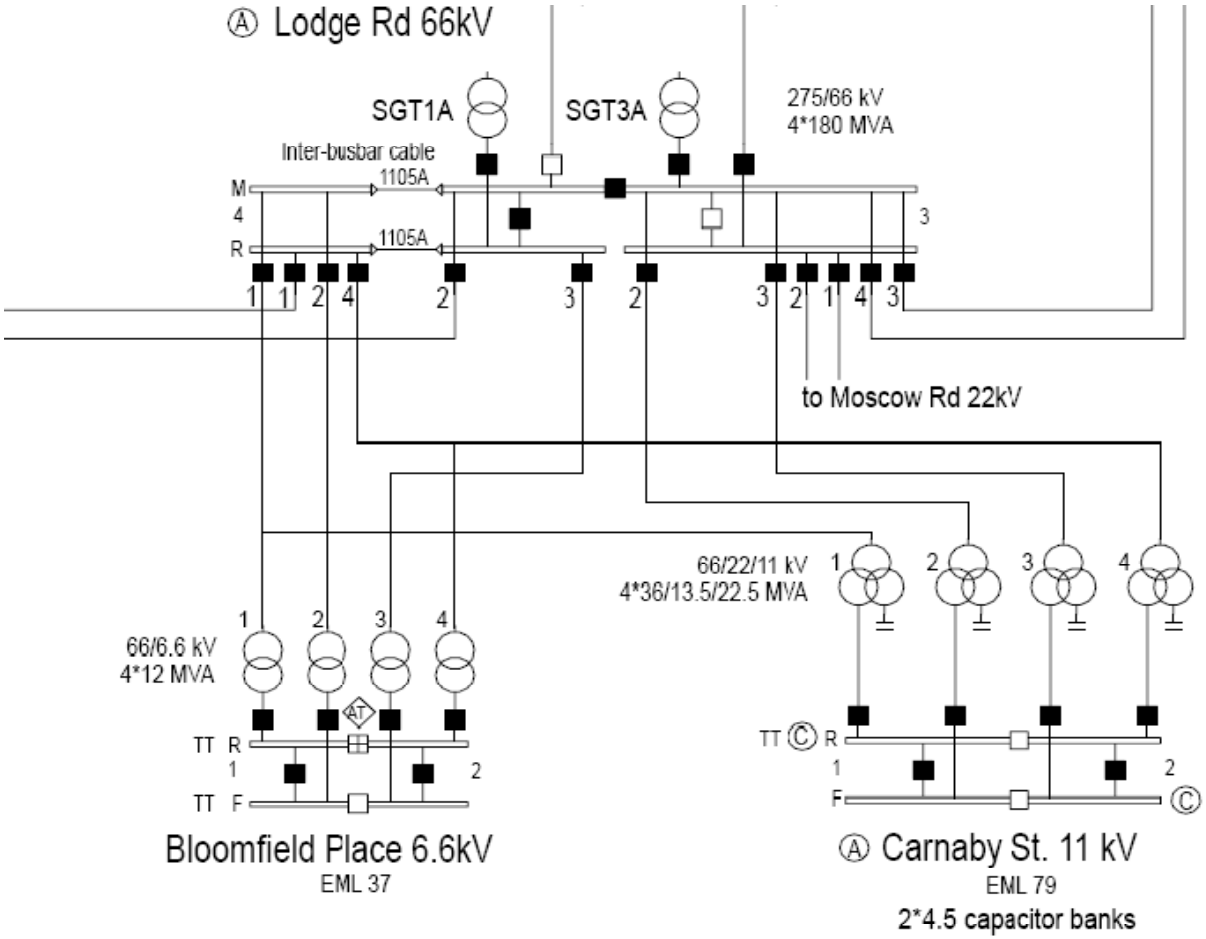
Carnaby Street 11kV substation



A HILP event – London West End – July 2006

Tuesday 25 July (17.32)

- Two coincident 66kV cable faults affected Carnaby Street substation (Circuits 2 & 3)
- Supply maintained but limited load shedding (4MW) and 14MW transfer effected
- Commercial load was at this point reducing into the evening (peak was 81MW)
- Faulty joint located on No.2 circuit overnight and 24-hour working commenced

Wednesday 26 July (05.01)

- No. 3 circuit restored after holding up under pressure test

Thursday 27 July (07.47)

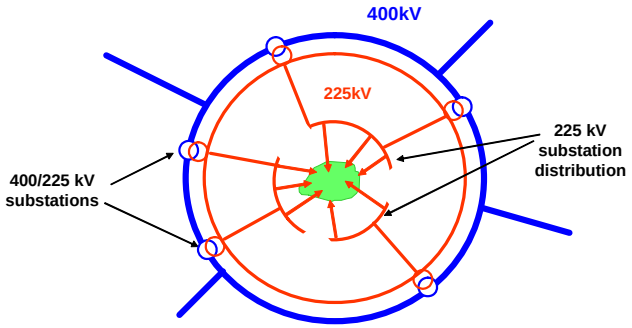
- No.3 circuit again tripped
- Commercial load now increasing into the working day
- One load block (feeder group) transferred
- Rota (4 hour) shedding instigated for remaining three feeder groups
- West End shops (incl. Oxford Street), offices, restaurants and theatres affected
- Media sought to link event to high temperatures
- No. 2 circuit returned to service 05.30 on Friday 28 July (2½ days to repair)

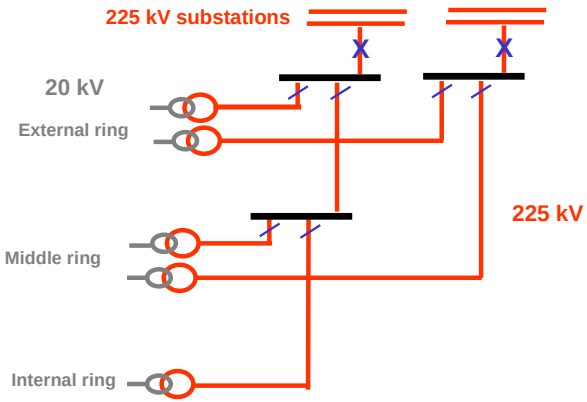
CBDs, HILP events & P2/6

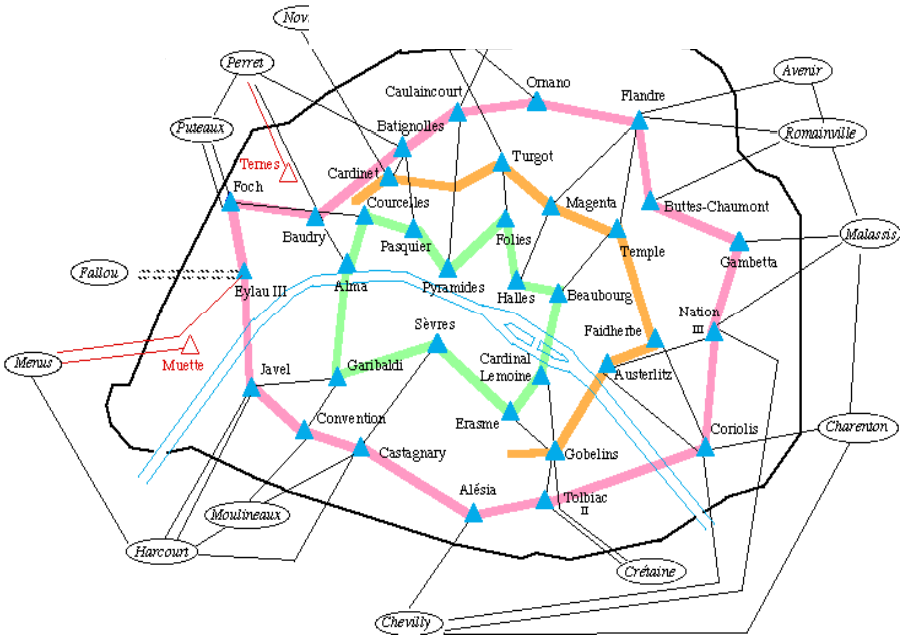
- Is the P2/6 design standard commensurate with a CBD?
- Would the consequences of a protracted outage in such an area be acceptable?
- The Auckland CBD power outages in 1998 led to New Zealand being likened to a third-world country
- The 2003 outage in London, although quickly restored, had a substantial impact on the transport infrastructure
- How does network resilience in London, or indeed other UK CBDs compare with that of competitor cities?
- A comparison with Paris is interesting

The Paris 225/20kV network (overview)

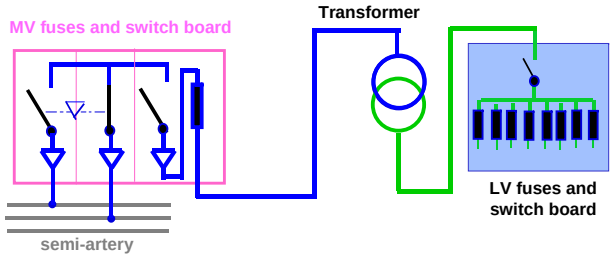
- 400kV mesh
- Radial 225kV connections
- 225kV radial can supply up to three 225/20kV substations
- 36 - 225/20kV substations
- 3 – 20kV 'open' rings

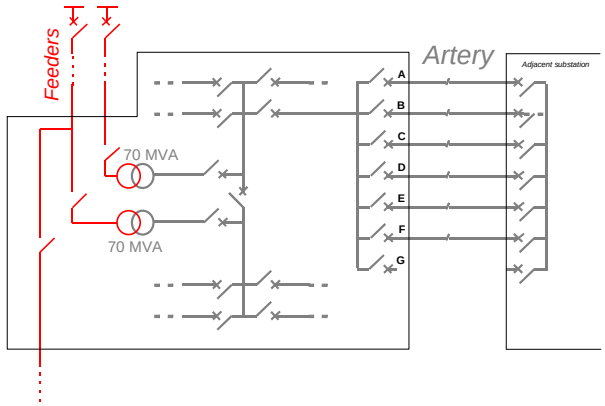




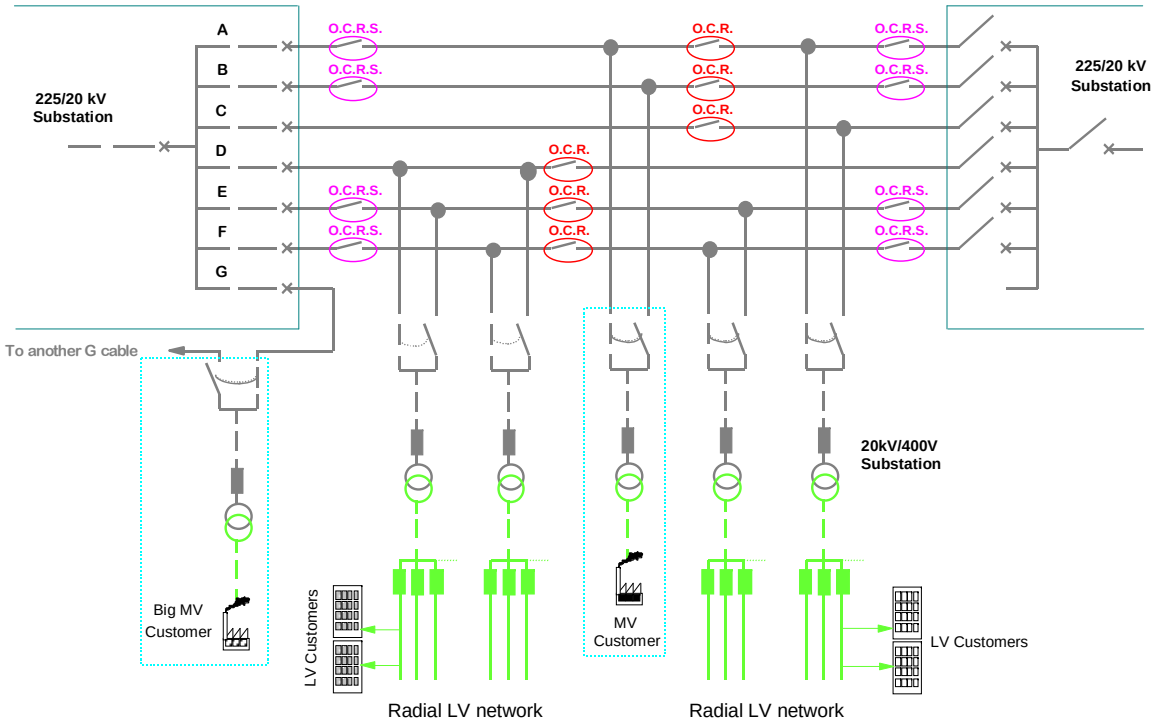


Paris – 20kV artery detail





225/20kV substations equipped with 2 – 70MVA or 1 – 100MVA transformers

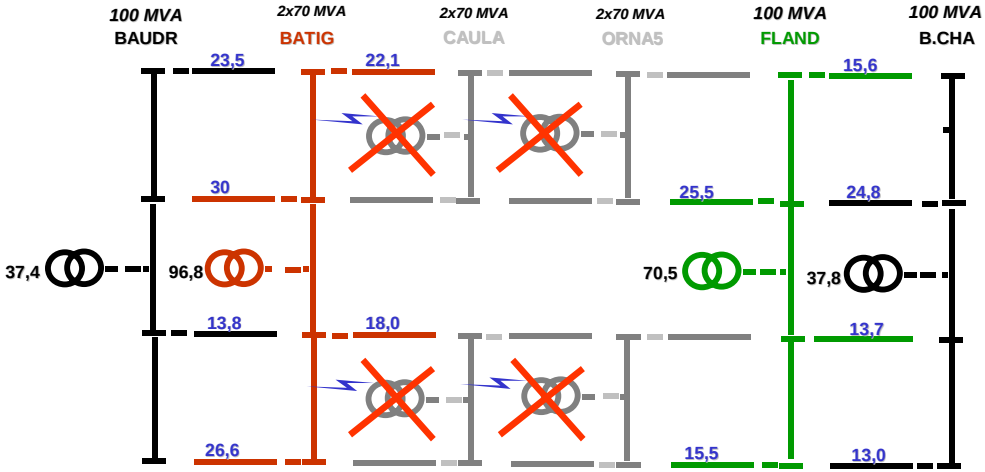


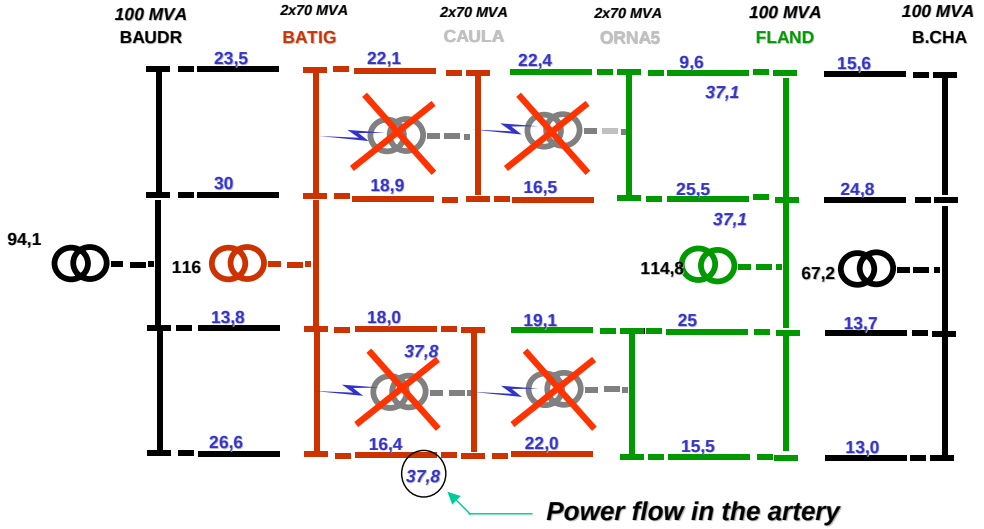
Loss of two adjacent 225/20kV substations

The network design allows for the loss of two adjacent 225/20kV substations.

The caveat is that this assumes normal temperature.

The effect of summer peak demand and hotter summers is a further factor that is starting to impact network capacity in inner city areas.





Do CBDs require higher security?

- Commercial losses can be massive (immediate and longer term)
- Significant societal impact:
  - Transport infrastructure paralysed
  - Telecommunications infrastructure overloaded
  - Potential for public disorder – even looting!
  - Genuine concerns over public safety
- One ‘customer’ can equate to hundreds of employees
- One interrupted customer may mean thousands of impacted people
- One major event could seriously undermine confidence in infrastructure
- Incalculable long term impact on UK economy
- Cost of mitigation may be a fraction of potential cost of just one HILP event