Overview of History and Benefits of CIGRE in Ireland

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CIGRE IRISH NATIONAL COMMITTEE

Pioneering approaches for renewable integration

Spirit of Technical Innovation

Nicholas Callan Professor of Natural Philosophy

at Maynooth College (now NUI, Maynooth)

Initiator of earliest electrical research in Ireland

1837: produced a giant induction machine using a clock mechanism to interrupt the current 20 times a second. The machine generated 60kV producing 15-inch sparks - largest artificially generated electrical flash ever seen at the time.

ESB Origins & History

1920s - 1930s

ESB founded 1927

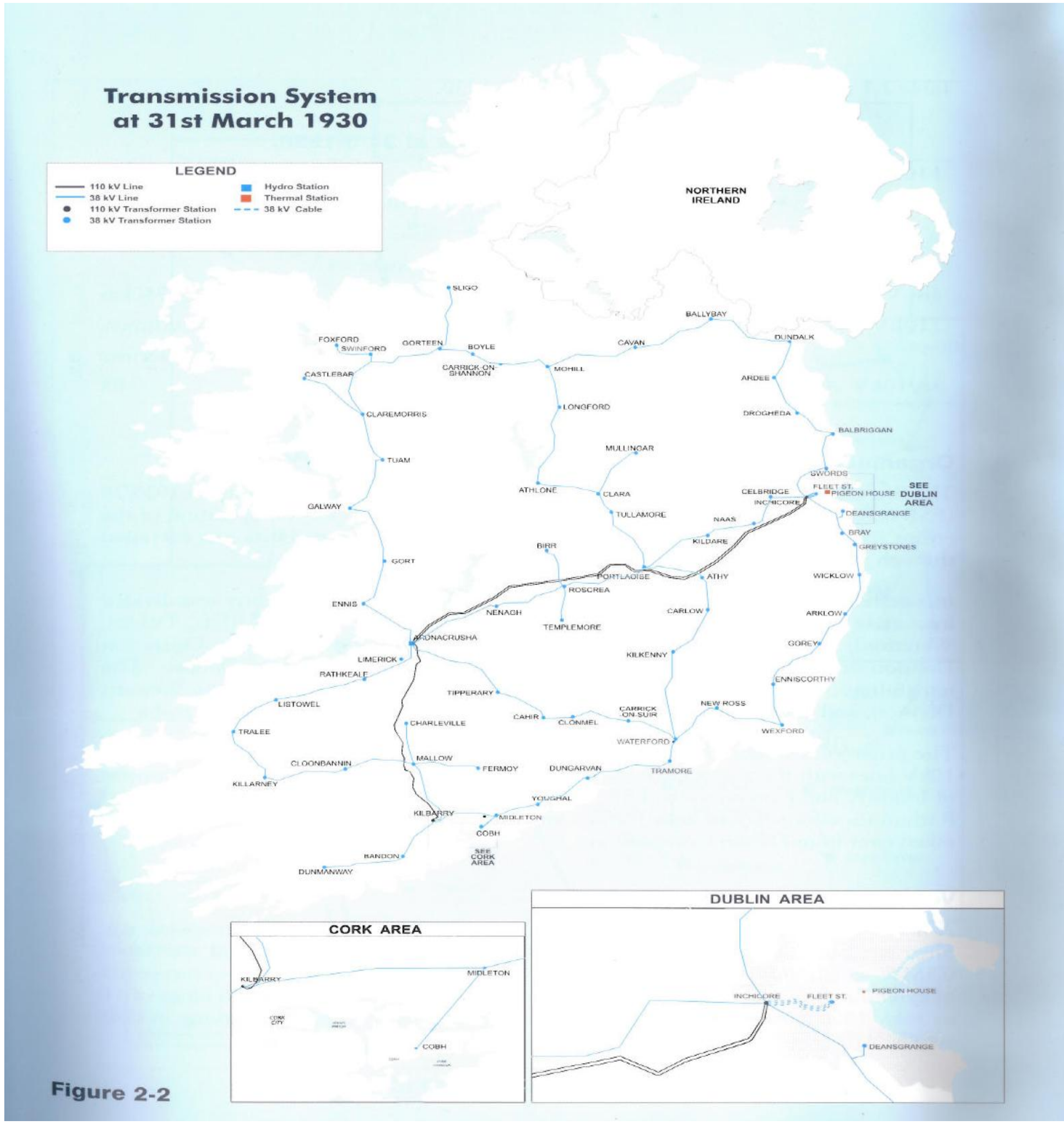
Development of hydro resources

1940s - 1960s

Rural electrification of Ireland

Development of peat resources

Ferbane Generation Station.



Transmission System
at 31st March 1930
LEGEND
110 kV Line
38 kV Line
110 kV Transformer Station
38 kV Transformer Station
Hydro Station
Thermal Station
38 kV Cable
NORTHERN IRELAND
SLIGO
BALLYBAY
DUNDALK
FOXFORD
SWINFORD
GORTEEN
BOYLE
CAVAN
CASTLEBAR
CARRICK-ON-SHANNON
MOHILL
ARDEE
LONGFORD
CLAREMORRIS
DROGHEDA
BALBRIGGAN
MULLINGAR
TUAM
SWORDS
ATHLONE
CLARA
CELBRIDGE
FLEET ST.
PIGEON HOUSE
SEE DUBLIN AREA
INCHICORE
GALWAY
TULLAMORE
NAAS
DEANSGRANGE
KILDARE
BRAY
BIRR
GREYSTONES
GORT
PORTLAOISE
ATHY
WICKLOW
ROSCREA
ENNIS
NENAGH
CARLOW
ARKLOW
TEMPLEMORE
ARDNACRUSHA
GOREY
LIMERICK
KILKENNY
RATHKEALE
ENNISCORTHY
TIPPERARY
NEW ROSS
LISTOWEL
CAHIR
CARRICK-ON-SUIR
CLONMEL
CHARLEVILLE
WEXFORD
TRALEE
WATERFORD
MALLOW
CLOONBANNIN
FERMOY
DUNGARVAN
TRAMORE
KILLARNEY
YOUGHAL
KILBARRY
MIDLETON
COBH
BANDON
SEE CORK AREA
DUNMANWAY
CORK AREA
DUBLIN AREA

Figure 2-2

ESB Development

- By 1950s the ESB's national electricity supply system had been established involving generation, transmission and distribution facilities.
- Playing a key role in Ireland's national economy
  - direct employment
  - purchase of services and plant
- Driving in the development and application of expertise in all aspects of engineering relating to the electrical power industry.
- Outward-looking in terms of ideas, initiatives, participation in technical institutions such as CIGRE

CIGRE in Ireland

1948: Dr. Robert C. (Bob) Cuffe, attends CIGRÉ session in Paris

1952: Becomes member attends session and explores with Mr Jean Tribot Laspiere Irish Membership as NC

"... it would be very valuable to have some younger members on the National Committee..."

Committee:

Mr. A. J. Litton. Assistant Chief Engineer, Department of Posts and Telegraphs,

Prof. J. J. Morrissey, Electrical Engineering, University College, Dublin,

Dr. J. J. O'Doherty, Head of Transmission Department.

Examples of Benefits in Irish Context

Three major projects undertaken over the past 30 years where CIGRE involvement was particularly beneficial.

Transmission Network Enhancement

- Conversion of the 110kV network from ASC to effectively earthed operation.

Dealing with Sudden Generation Loss in an Island Utility

- Automatic Frequency Activated Load Restoration
- Load Wind-down

110kV Neutral Earthing

Until June 1979 110kV network consisted of two sections (North and South) each arc suppressed and interconnected through the superimposed fledgling 220kV Network.

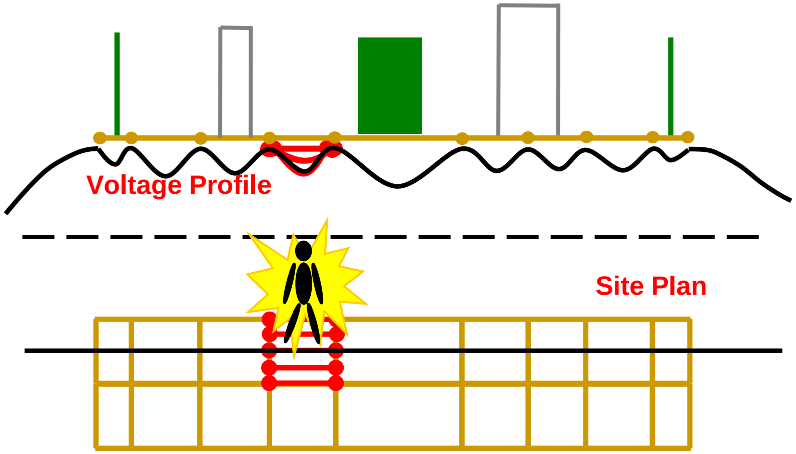
Necessary to change to effectively earthed system because:

- Safety: expanding constituent networks nearing the limits of successful ASC fault arc extension
- Economic: possible to introduce less expensive autotransformers for 220/110kV interconnection
- 110kV interconnection to NIES - already effectively earthed

BUT!!!!!

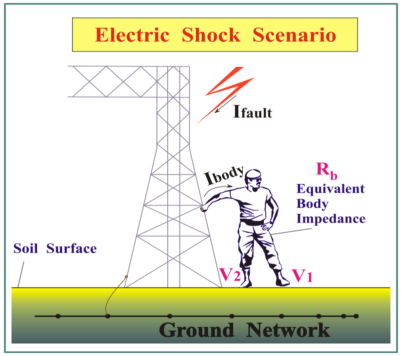
Challenges

Older substation earth grids not always rated for high ground fault currents – unacceptable touch/step voltages



Absence of earth wires on the 110kV overhead line configuration exacerbated the situation as tower footing resistances were frequently very high:

- Hazards for humans, animals, equipment
- Interference with telecomms facilities



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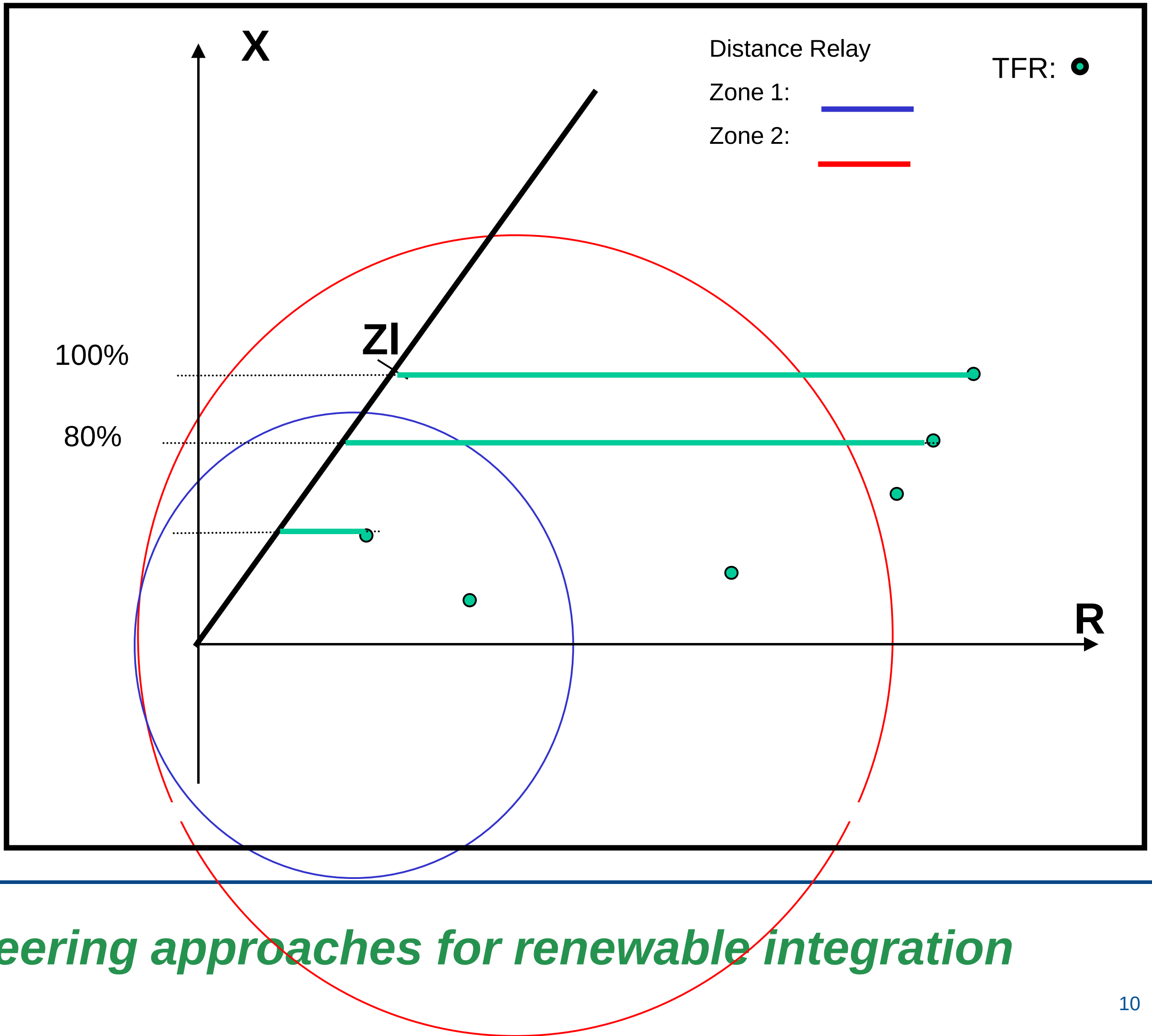
Pioneering approaches for renewable integration

Challenges

Control and protection systems had not been designed to cater for single phase to ground short circuits.



Relaying Issues

- Based on ITU (CCITT) recommendations fault clearance should not exceed 0.6 seconds
- Quickly established that existing line distance protection was in numerous instances inadequate due to the high fault resistance of many towers
- Alternative solutions required but none readily available
- Extensive studies simulating protection performance for different values of TFR all 110kV lines

Relaying Studies Conclusions

- Assessment of Distance Relay performance
  - Fail in many cases
  - TFR treatment alone inadequate
- Evaluating potential solutions also based on studies
  - Sensitivity/speed: all faults cleared in less than 0.6sec
  - External fault discrimination
  - Autoreclose capability

Directional Comparison Earth Fault Function

Pioneering approaches for renewable integration

CIGRE Benefit

- CIGRE contacts confirmed situation while unusual was not unique
- Responses to presentations at the CIGRE sessions on the studies and investigations undertaken affirmed the approach
  - A similar situation existing in another utility warranted the application of a special purpose earth fault relay.
- This gave confidence in adopting such a solution which in ESB's case necessitated the application of a special relay not yet commercially available and the widespread deployment of associated teleprotection links.

Directional earth fault relay was produced by Siemens to which design ESB contributed significantly.

It was successfully deployed throughout the 110kV network. Even with such relays however it was still necessary to undertake a programme of tower footing assistance reduction.

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Sudden Generation Loss on an Islanded System

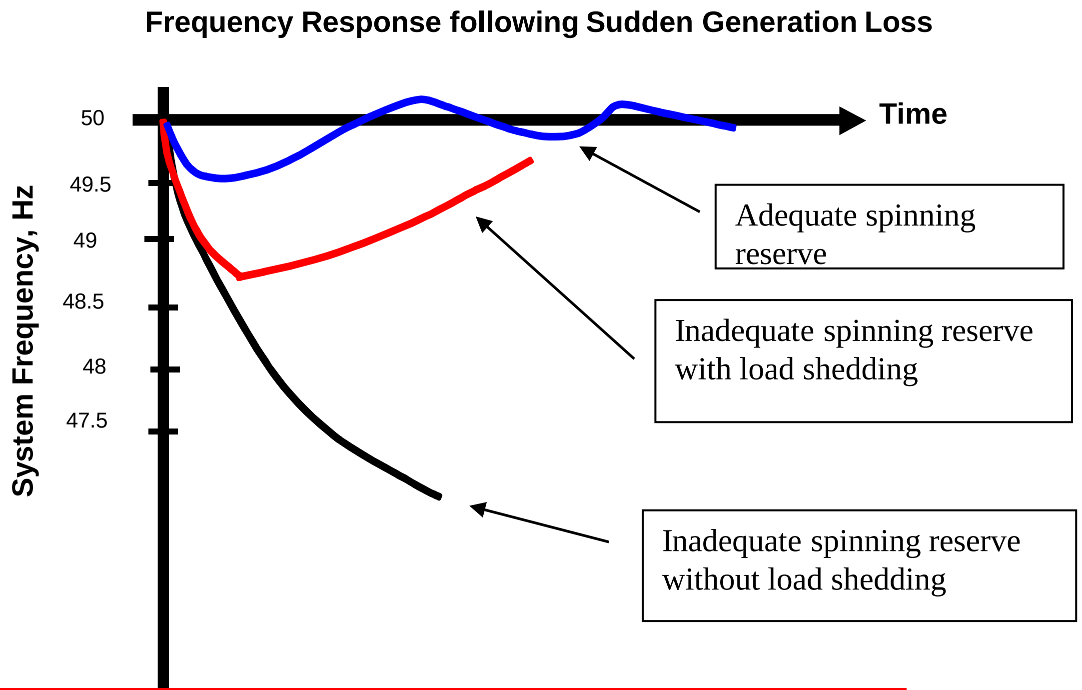
- Generation was predominantly oil based – extremely expensive post 1973, 1979 oil shocks
- Rating of the high merit units (250, 270MW) selected on basis of thermal efficiency
- Spinning reserve, also oil sourced, was very expensive.

Reduce levels of spinning reserve while maintaining acceptable levels of supply security.

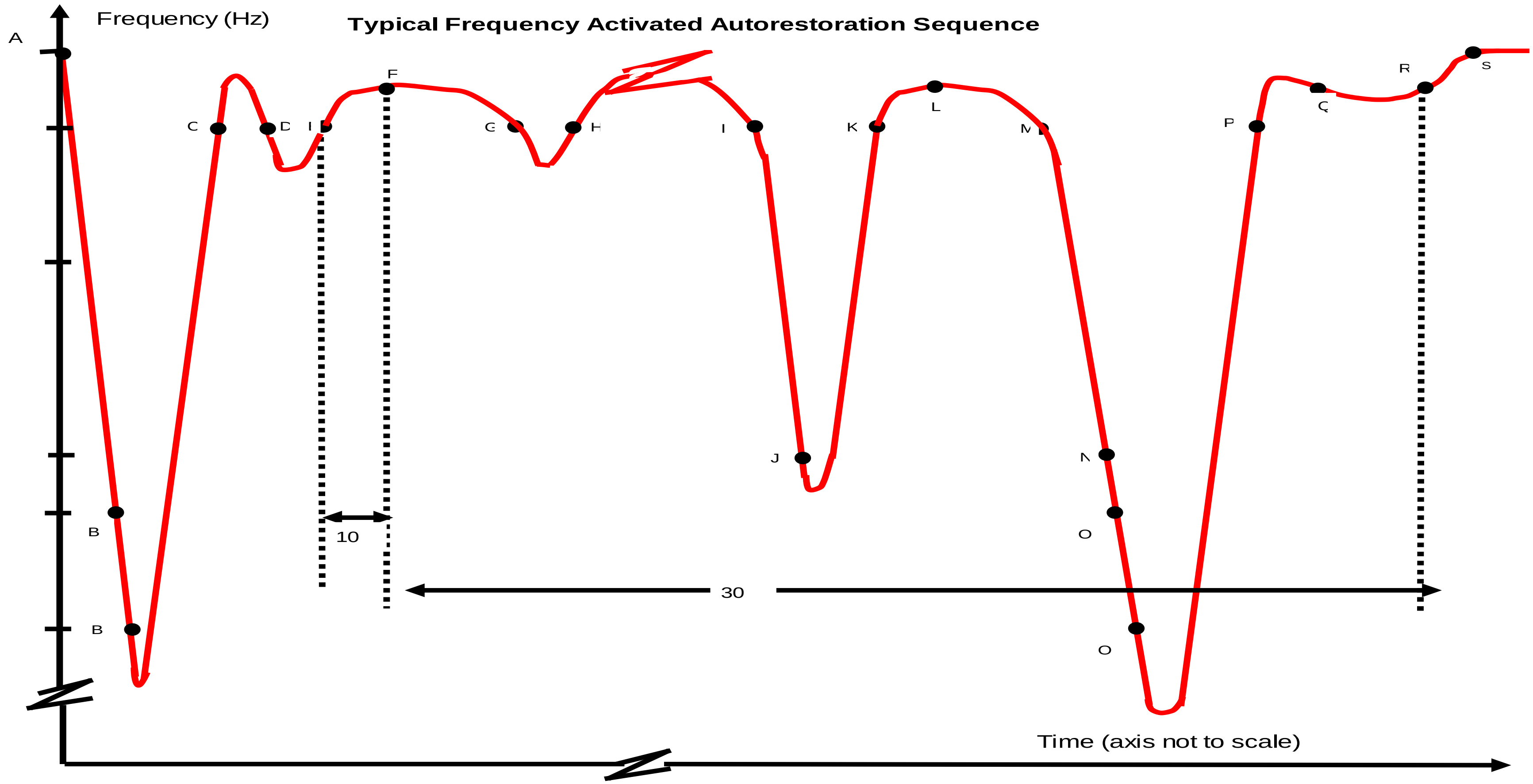
- Frequency Automated Load Restoration
- Generator Load Wind-Down

Frequency Automated Load Shedding/Restoration (1985)

- 60% Load shed in 4 steps on falling frequency
  - 48.5, 48.4, 48.3, 48.2 Hz
- All shed load restored manually
  - slow process



All shed load restored automatically on rising frequency?



Sequence:
1. A: Frequency stable at 50Hz (pre disturbance)
2. During disturbance frequency declines,at B1 (48.8Hz) AFR scheme triggered; at B2 (48.5Hz) underfrequency load shedding commences.
3. Frequency recovers to above C (49.8Hz); no restoration as frequency again declines (D) before the initial restore timer setting (10secs) is exceeded.
4. Frequency again recovers above 49.8; when time E-F elapses restoration commences and proceeds to G when frequency has dropped below 49.8 restoration is interrupted
5. At H restoration immediately resumes and continues until I.
6. At J a sinificant frequency decline (<49Hz) occurs; restoration is interrupted and the initial delay time is reintroduced.
7. On recovery to 49.8Hz restoration proceeds K-L-M exactly as for E-F-G previously.
8. N-O1-O2 represents a serious frequency decline such that restoration interrupted at M, initial delay reintroduced at N, scheme reset at O1 and load shedding takes place for the second time at O2.
9. Restoration sequence recommences at P and proceed until load is eventually restored P-Q-R-S by which time the frequency has recovered to its normal value

CIGRE Benefit

- Significant dialogue with CIGRE colleagues in other utilities and manufacturers
- Papers presented by ESB at CIGRE conferences well received
  - some references to similar proposals elsewhere were obtained.

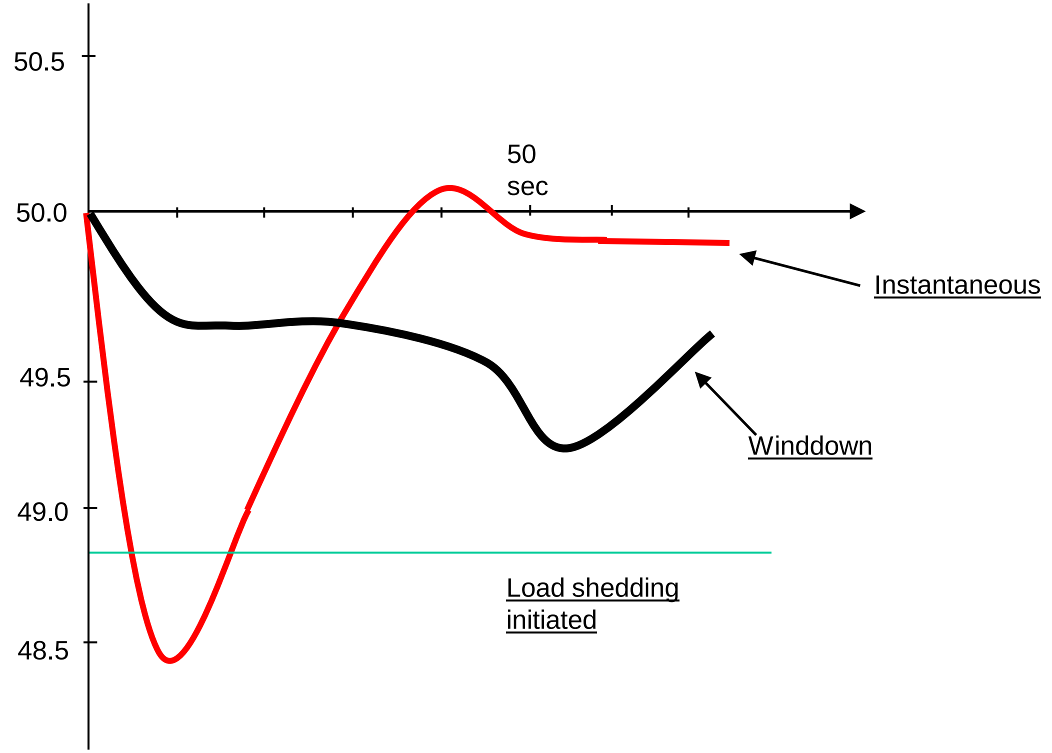
Following deployment on the 38kV feeders in 110kV stations first restoration units commissioned in 1983

Performance over the next decade was good.

Year	Severity (System-Minutes)	%Shed Load Automatically Restored	Frequency Stabilisation to Restoration (Minutes)
1987	2.91	81	4
1987	1.73	66	4
1993	7.3	97	5
1994	4.73	86	4

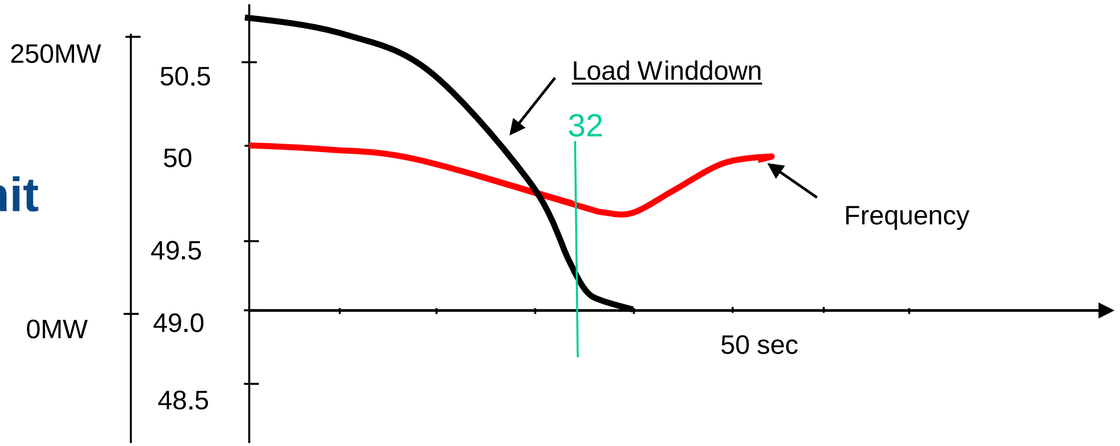
Load Wind-Down

- High risk of widespread load shedding in the event of a large unit instantaneous trips
- Investigation found that for many boiler faults, load could be “wound down” over a 30-60s period rather than instantaneously tripping the unit [in fact this accounted for over 70% of tripping that had been occurring on thermal units at the time.]

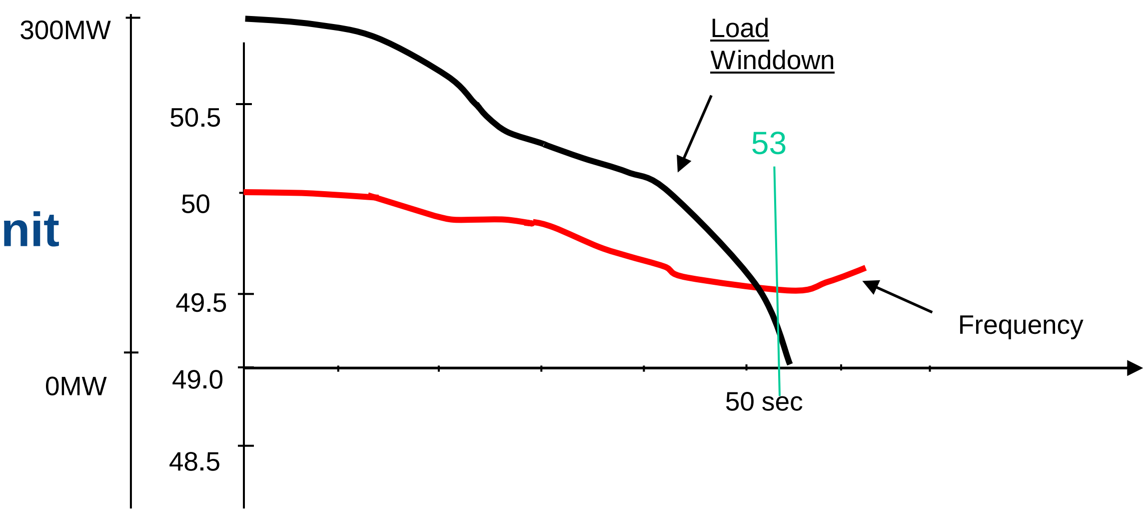


Test Results

270MW Unit

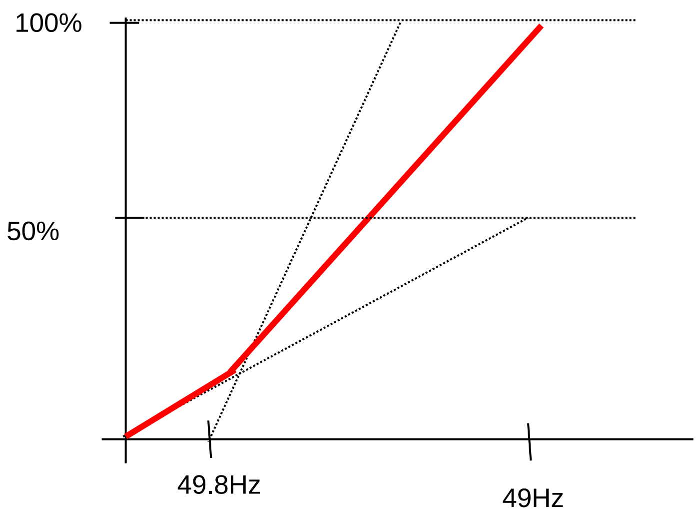


300MW Unit



Conclusions of Investigation

- Wind down is not applicable in all cases (e.g. most generation electrical faults) instantaneous tripping is sometimes required – available time for reserve support ca. 6 s.
- Investigation determined response levels and response speed of gas turbines, conventional thermal and pumped storage; solution adopted utilised these characteristics
  - e.g. the simple cycle GTs fitted with dual gain governors to accelerate response on rapidly dropping frequency where the regulation is decreased from 4% to 2% as deviation approached 1Hz thus catering for case of instantaneous thermal unit trip.



Following wind down the rate of frequency decline is lower, the higher regulation is retained and in fact initiation signals can be sent to other plant that can reach full load within 30s.

CIGRE Benefit

- Dialogue with CIGRE colleagues in other utilities and manufacturers
- Papers presented by ESB at CIGRE conferences well received
- Enhanced confidence in applying a novel solution to a problem peculiar to an islanded system

Summary of benefits

Cigre been a major influence for staff development in terms of:

- Expertise development
- Confidence in technical ability
- Source of expert information and experience
- Particular source of support during major technical developments

Thus, CIGRE is not only a state of mind. It also represents a type of spirit, a spirit which has often been called the CIGRE spirit.

Mr. Mercier, chairman of CIGRE in 1948