Frankfurt (Germany), 6-9 June 2011

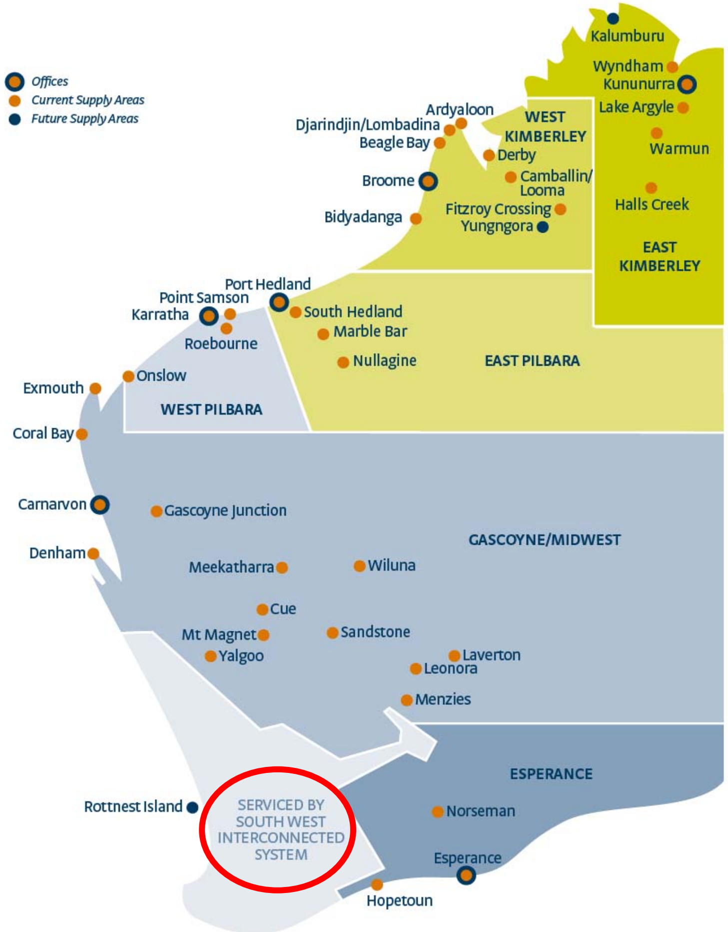
A BALANCED SCORECARD APPROACH FOR THE ENHANCEMENT OF DISTRIBUTED RENEWABLE PENETRATION LIMIT IN ISOLATED NETWORKS

Presented by: Dr. Worawit Tayati

Outlines

- Introduction
- Problem definition
- Methodology
- Study results
- Conclusions
- Discussion

Horizon Power – Who are we?



- Vertically integrated
- State owned
- Service regional towns and remote communities
- 2.3 Million sq.km
- 43,000 customers
- Excluding the South West Interconnected System (SWIS) ~700,000 cust.

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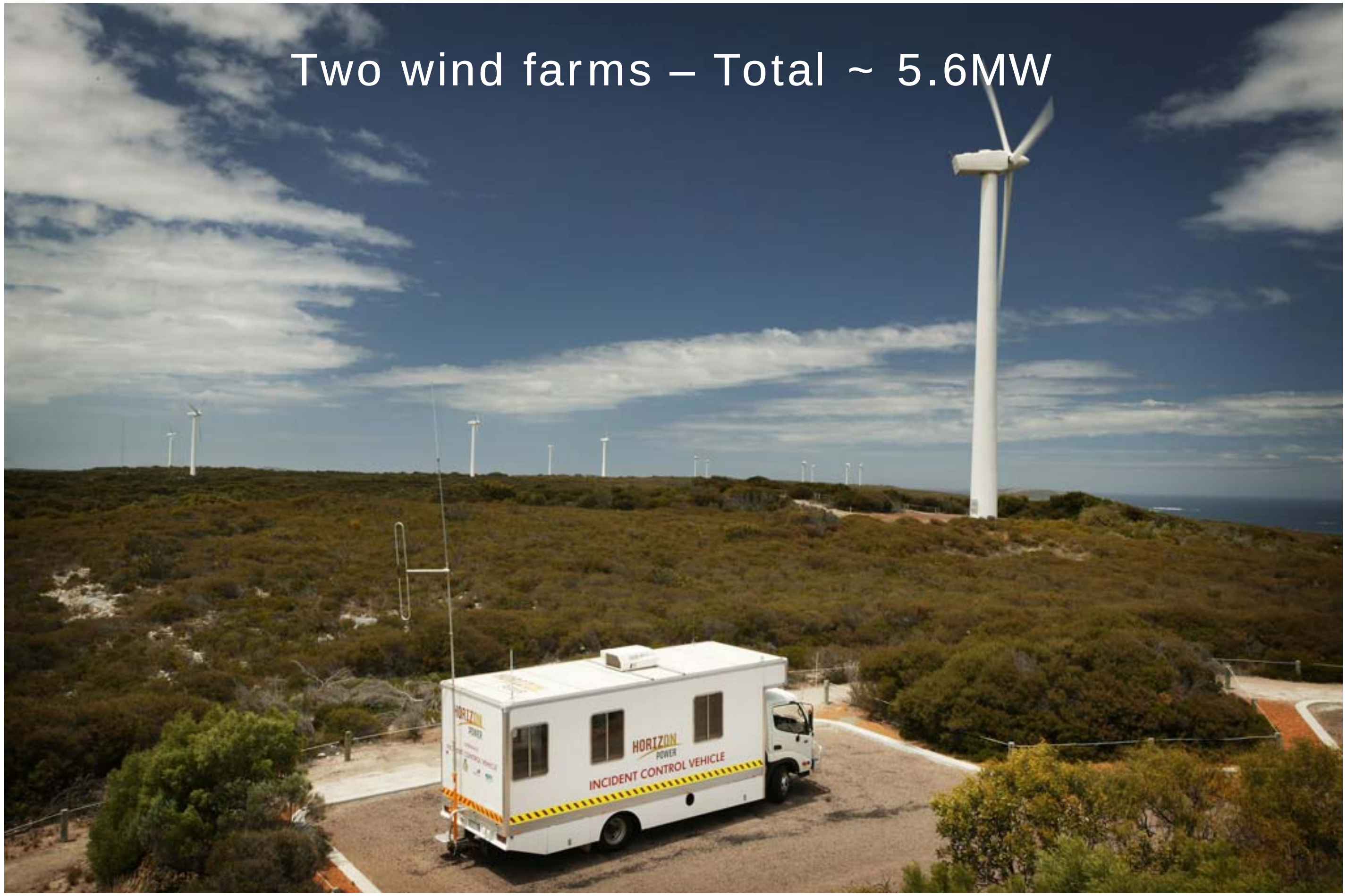
Our service area

- 30 isolated systems
  (~0.2 – 30MW)
- The North West Interconnected System NWIS (~500MW)
- Fuel mix – Gas, diesel
- Hydro - North East
- Wind - coastal
- Solar PV – inland
- Controlled and centralised RE systems

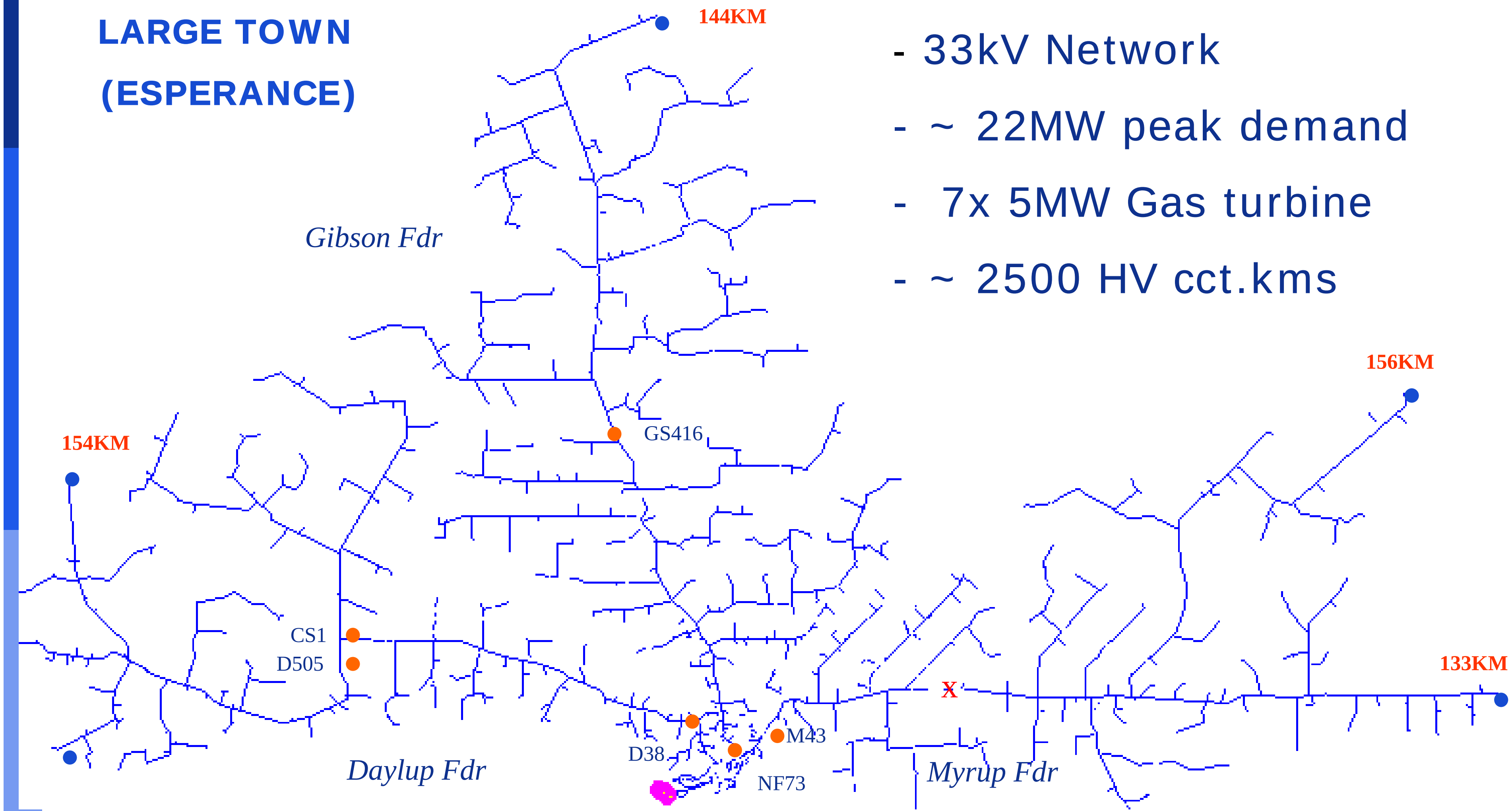
PV / Diesel / Flywheel hybrid system

Integration of Wind - Esperance

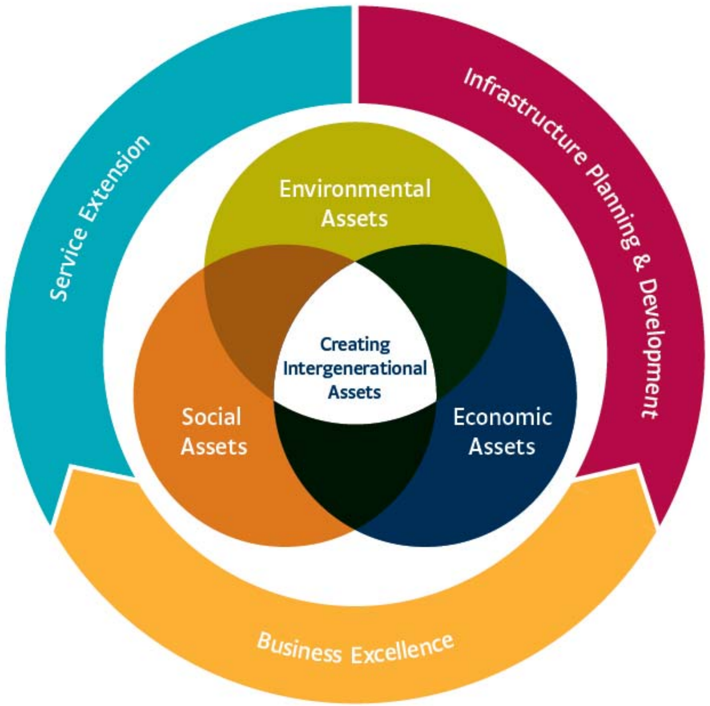


LARGE TOWN (ESPERANCE)

- 33kV Network
- ~ 22MW peak demand
- 7x 5MW Gas turbine
- ~ 2500 HV cct.kms



Our Strategy Wheel



- Cost of energy
  - 0.23 - 1.68 $/kWh
- GHG Emission
  - 0.68 kgCO2e/kWh
- Reliability (/yr/cust.)
  - SAIFI -2.43 (6.6*)
  - SAIDI-162 (290*min)

*Target

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Problem & Drivers

Drastic increase in PV installations exceeding current limits

- Abundant solar resources
- Decreasing PV panel cost
- Generous Government Incentives
  - RECs - capital cost subsidy
  - FiTs (40c/kWh) - net feed-in

Technical Issues

- System reliability concern
  - Small, isolated systems
  - Low fault level, low inertia
  - No other sources of supply
  - Extensive HV overhead networks

- LV / MV voltage rise issue
  - Evidence of customer PV inverters trip off
  - LV network operating voltage sets too high

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Methodology

- Reviewing existing penetration limit
  - Stability and network design
- Identifing enhancement strategies
  - Power station and network
- Assessing - balanced scorecard
  - Strategy wheel, technical, commercial aspects
- Validating – a case study

Existing limits

Supply Quality = PQ + Reliability

- Power station (P/S) limit : reliability
  - Step load < unit rating (N+1 spinning reserve)
  - Stand alone = no other sources of supply

- Network limit : power quality (PQ)
  - LV PV <20% of Tx rating – islanding
  - LV/MV voltage rise

Rule of Thumb

PV limit is the minimum of the followings:

- 50% smallest generating unit
- 15% of peak demand – diesel generation
- 10% of peak demand – gas generation

And :

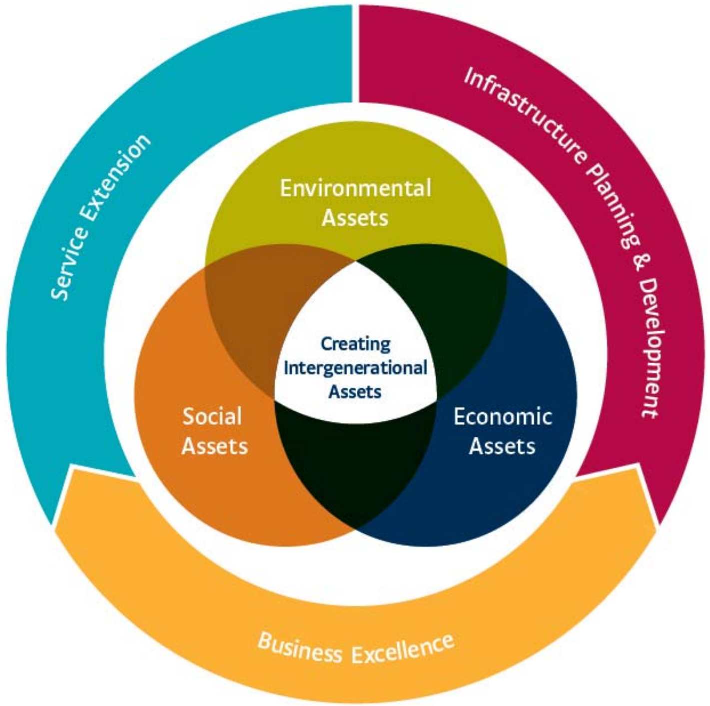
- De-rating of PV output due to temperature and inverter efficiency by ~70%

Enhancement strategies

- Power quality (PQ)
  - Network reinforcement (NR)
  - PV inverter sophistication - output curtialment
- Reliability
  - Under Frequency Roll Off (UFRO)
  - Extra spinning reserve (Ex SR) + PV forecast
  - PV Fault Ride Through (FRT)
  - Distributed UFLS - demand response
  - Energy Storage (ES) & AMI

A Balanced Scorecard (BSC)

- Economics
- Environmental
- Social - Customer equity
- Technical
  - Effectiveness
  - Uptake
- Commercial
  - IPP contracts <10% RE



CASE STUDY - Carnarvon

Selection Criterion:

- PV penetration exceeding current limits
- Horizon Power owned P/S
- New P/S under construction
  - Opportunity to implement innovative enhancement strategies
- Centralised wind energy integration envisaged

Outlines

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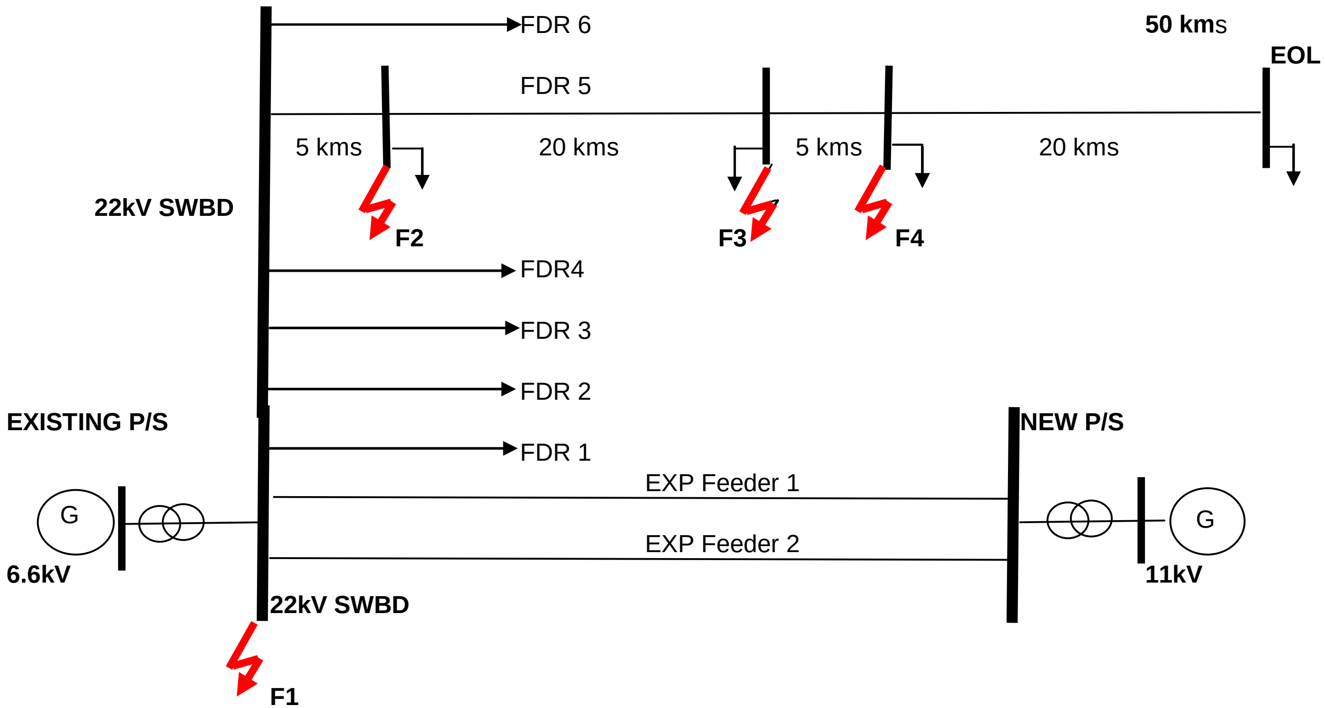
Network Fault Studies

Impact of network faults on distributed PV



Network Fault Studies

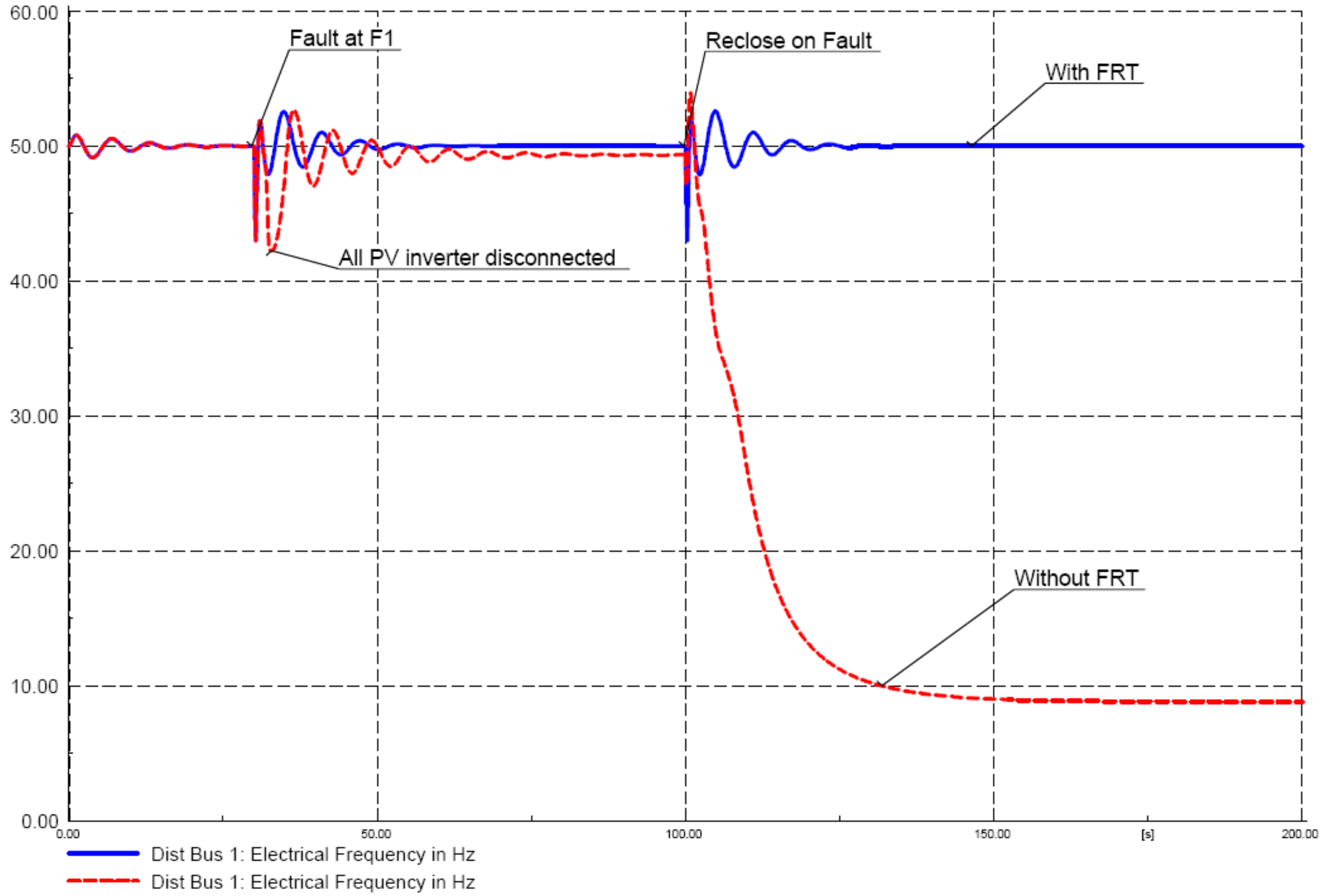
- Faults near to P/S, voltage depression
- Faults away from P/S, system frequency dips (due to high R/X ratio)
- PV inverters may trip on UV or UF

"Adverse impacts on power station stability"

PV Fault Ride Through

- Investigate effects on PV of network faults followed by feeders trip and reclose
- Determine effectiveness of PV FRT functionality

"PV FRT enhances system reliability"



BSC for Carnarvon

BALANCED SCORECARD		NR	UFRO	FRT	UFLS	ES	AMI	Ex SR
		1	2	3	4	5	6	7
ECONOMIC	COST	Yellow	Orange	Yellow	Orange	Red	Red	Orange
ENVIRONMENTAL	EMISSION	Green	Green	Green	Green	Yellow	Green	Red
SOCIAL	EQUITY	Green	Green	Green	Green	Green	Orange	Green
	ACCEPTABLE	Green	Green	Green	Red	Green	Green	Green
TECHNICAL	EFFECTIVE	Green	Yellow	Yellow	Red	Green	Orange	Green
	UPTAKE	Yellow	Yellow	Red	Orange	Green	Red	Green
COMMERCIAL	IPP CONTRACT	Green	Green	Green	Green	Orange	Green	Red
OPERATION	SIMPLICITY	Green	Yellow	Orange	Green	Orange	Green	Red

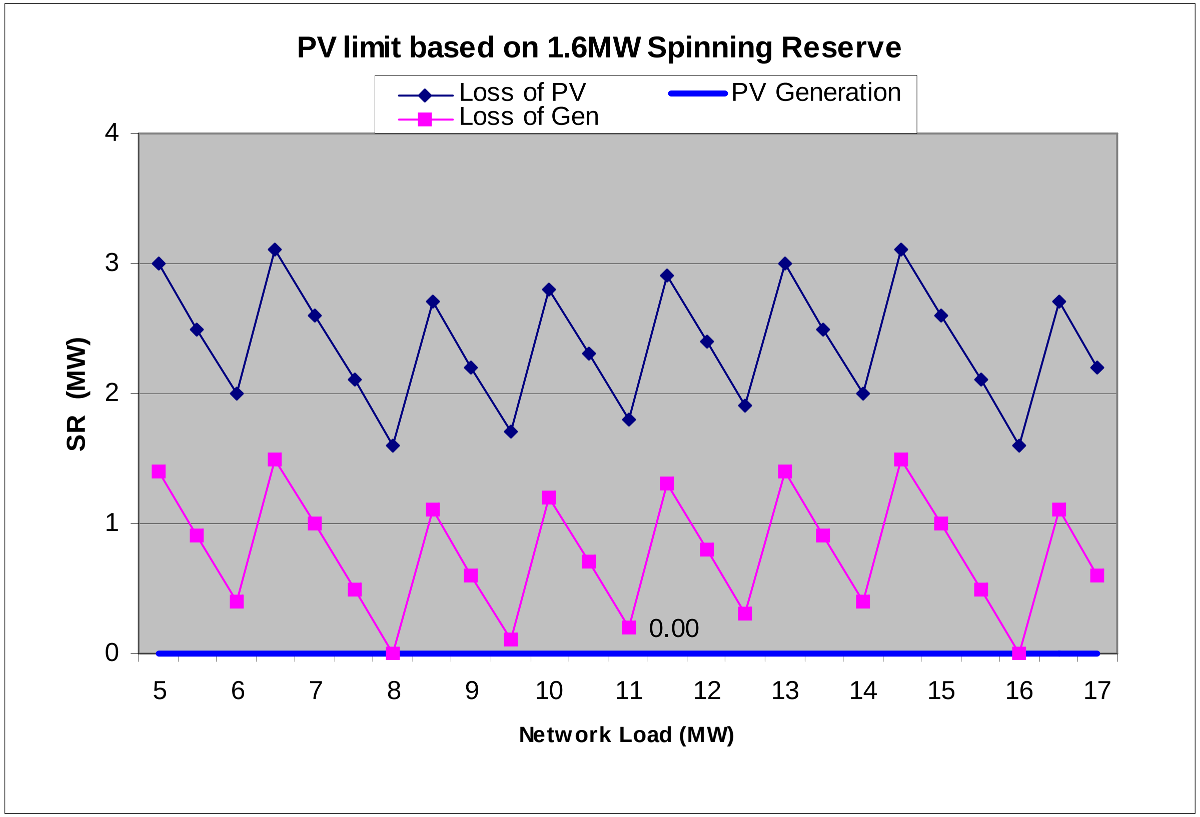
Legend: Good (Green) | Fair (Yellow) | Poor (Orange) | Bad (Red)

Summary – Case Study

- Network Reinforcement (NR) recommended
- UFRO recommended for new P/S
- PV FRT considered, improve reliability
  - Proven technology, uptake?
- UFLS – uptake?, effectiveness?
- Energy storage – cost barrier
- AMI – uptake?, cost
- Extra SR – commercial contract, more emission, cost

Spinning reserve

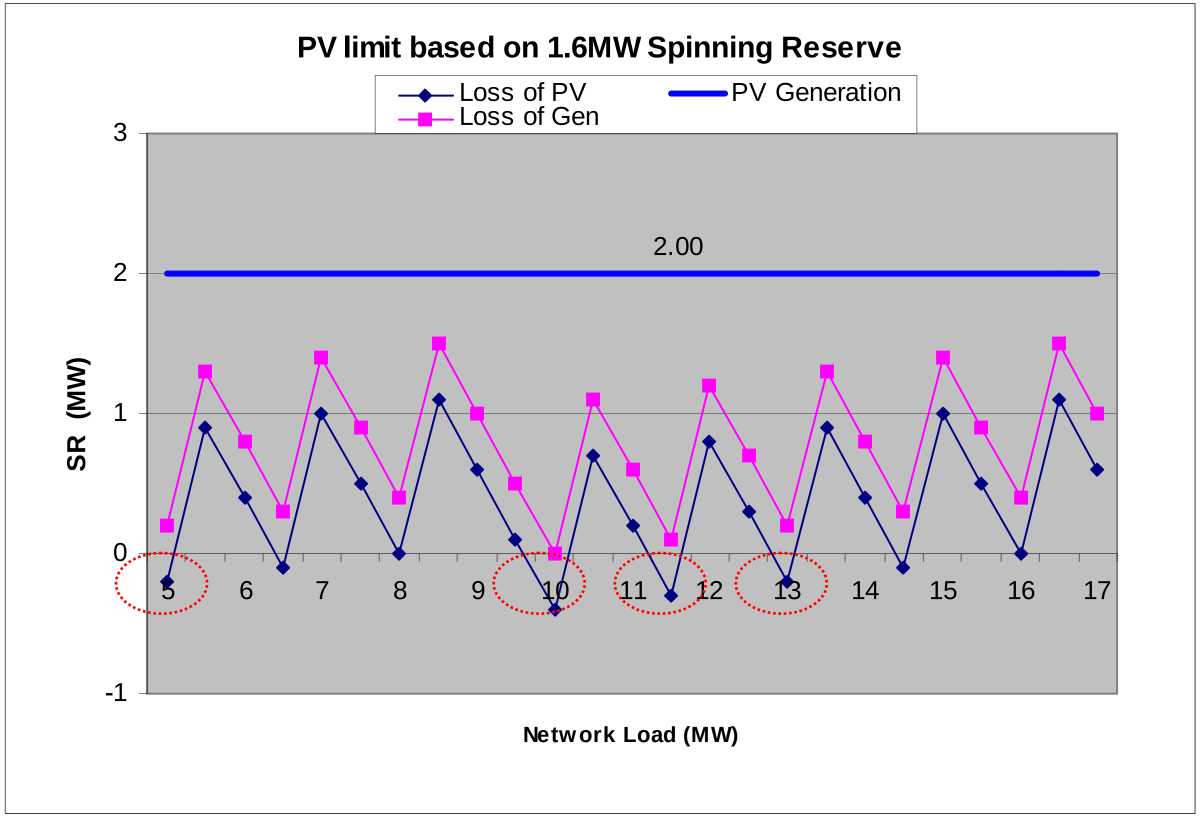
(Based on N+1 operating philosophy)



Loss of Total PV

Loss of Single Unit

Possibility of Higher PV Penetration



Loss of Single Unit

Loss of Total PV

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Conclusions

- Small power system supply quality is susceptible to level of distributed PV penetration
- Expectation to accommodate distributed PV
- Our deterministic limits based on spinning reserve may be too conservative
- There are opportunities to increase decentralised PV penetration limits using a risk based probabilistic approach e.g.
  - Probability of not all PV disconnecting following faults
  - Probability of fault frequency (fault rate)
  - Probability of PV output not at installed capacity (temperature, cloud cover, incident angle, etc.)

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THANK YOU FOR YOUR ATTENTION

QUESTIONS?