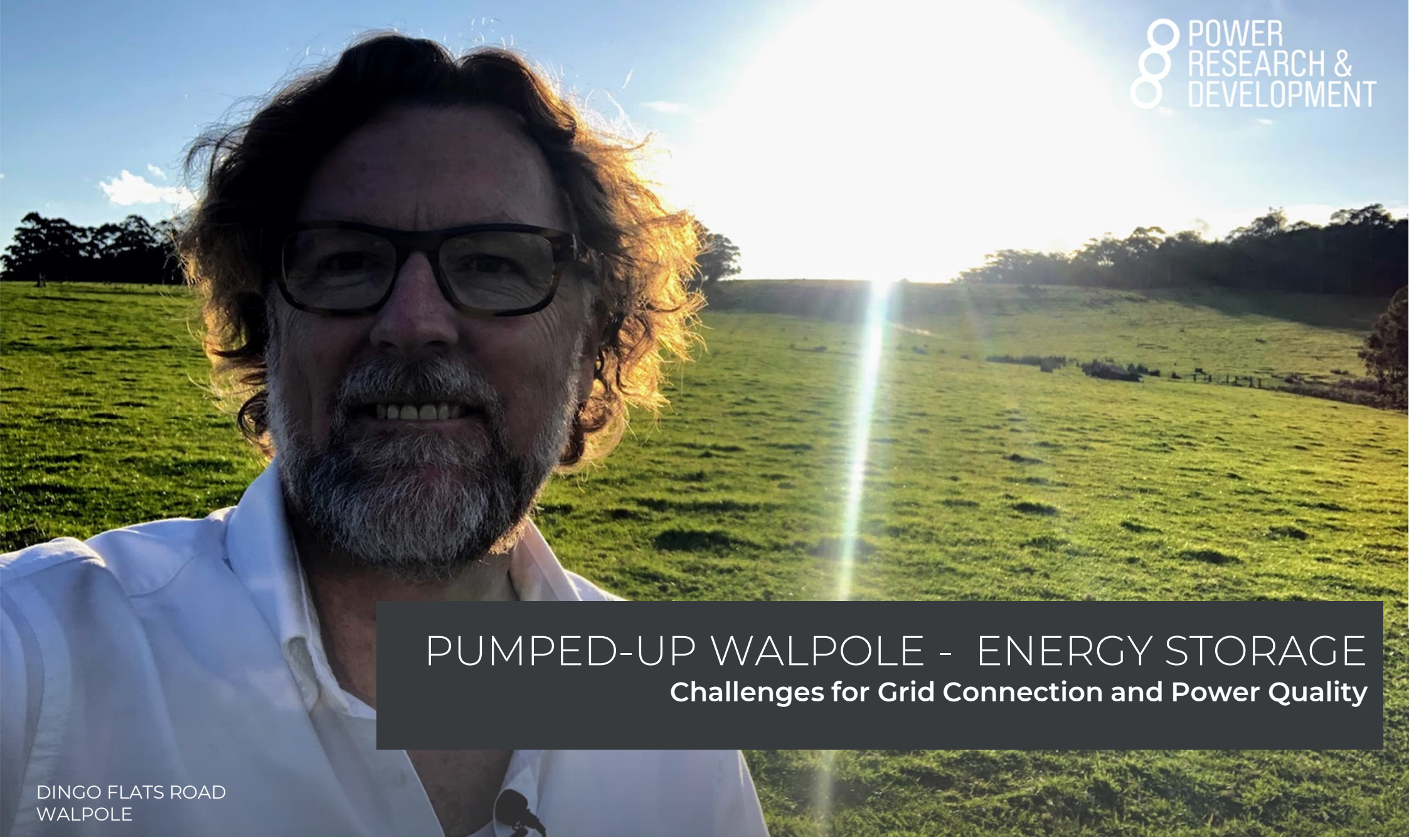


PUMPED-UP WALPOLE - ENERGY STORAGE

Challenges for Grid Connection and Power Quality

DINGO FLATS ROAD
WALPOLE

EESA and Engineers Australia – SEPTEMBER 2023

project is supported by

Government of **Western Australia**
Department of **Water and Environmental Regulation**

CLEAN ENERGY FUTURE FUND

RATIONALE

Q1 - WHAT is ELECTRICITY MARKET - 30 YEARS IN FUTURE?

A - Mix of mainly intermittent generation plus:

- smart grids & DSM (rational economics, may dominate, takes time)
- distributed energy & storage (discretionary and mostly sentiment)
- bulk storage 1 to 20 hours (rational economics)
- fully digital

Q2 - HOW to DELIVER NOW?

A - Economic bulk storage to 20 hours:

- Eliminate constraints (100m elevation, farm dams, unlimited locations)
- Incremental like wind turbines and PV, not niche
- Economic **=** storage $ + PV/wind + network **<** black power $ + network
- Template for streamlined grid connection
- Futureproof, fast to deploy and scalable

BACKGROUND

- Triggered by NEM case
- Energy markets are in transition - mixed signals
- Accelerate transition

DEMONSTRATE at WALPOLE

then:

- ➢ Enable mass production
- ➢ Streamline operation
- ➢ Systematic deployment
- ➢ Demand-driven rollout

1. Pumped-Up Walpole
   - Functions
   - Arrangement
2. Challenges and solutions
   - Power quality
   - Wide area networking
   - Resilience & flexibility
   - Capital efficiency
3. Questions

125 kilometre distribution line through karri forests, storms and bushfires

Western Power and PRD joint **renewable microgrid** project will significantly improve power **reliability for Walpole**

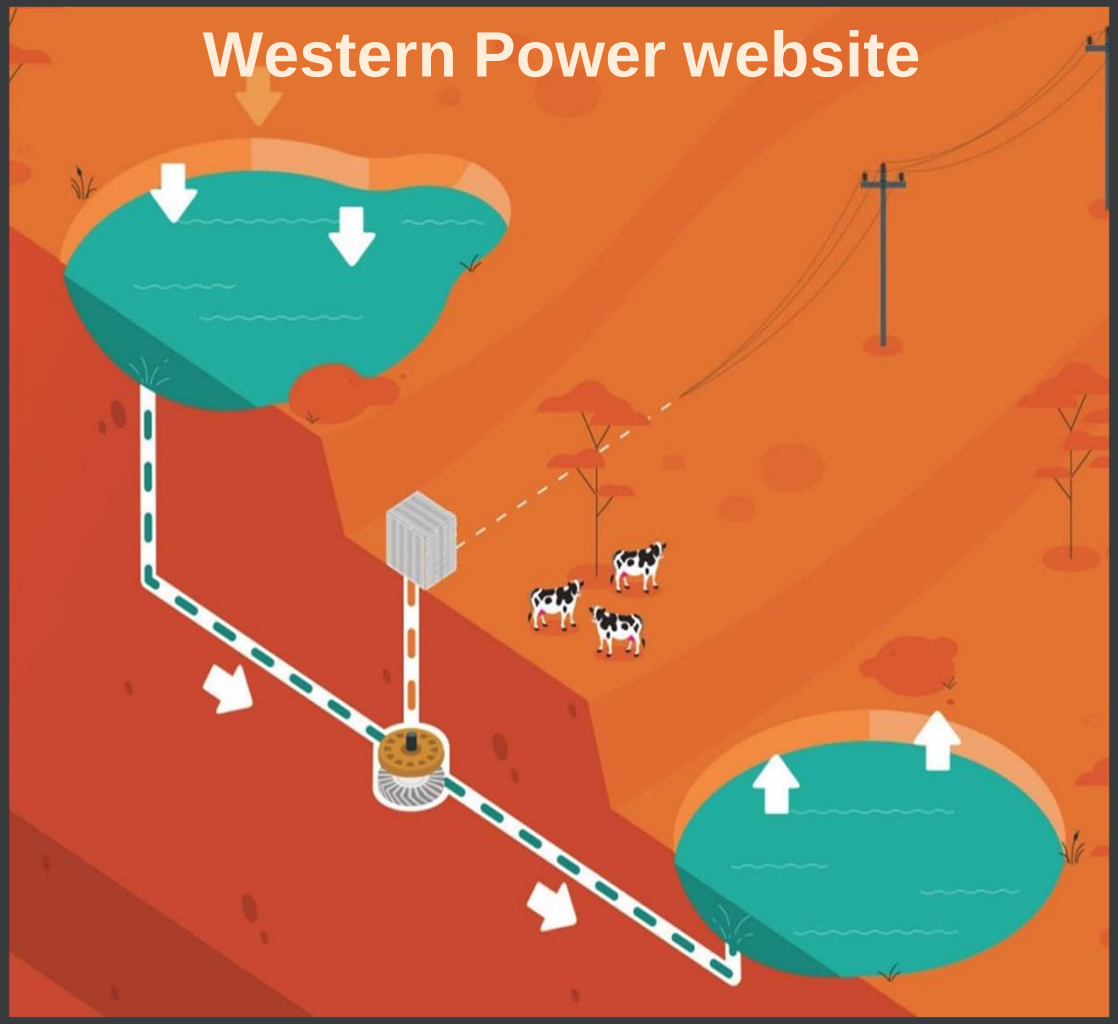
Awarded $2 million as part of the WA Government's Clean Energy Future Fund

"This project, despite being on a **smaller scale**, will be used as a **template** for other areas in the State, and possibly nationally and internationally."

Bill Johnston - WA Minister for Energy

1. Pumped-Up Walpole

POWER RESEARCH & DEVELOPMENT



WALPOLE FUNCTIONS

- Network Control Services - reliability
- Assigned Reserve Capacity
- WEM wholesale energy trading
- Embedded solar PV
- Retail bulk energy storage service

OTHER CAPABILITIES

- Network Control Services voltage support, peak lopping and demand management
- EV supercharging hub
- Ancillary Services

LONG-TERM STORAGE

- 1.5MW
- 20 hours hydro capacity

PATENTED SYSTEM

- Microgrid enabled (grid forming) - Walpole average demand is 400kW
- Fully inverter connected
- 15 min integrated battery
- Sophisticated automation
- Instant and bumpless transitions

Two farm dams, 170ML and 2ha each

85m elevation difference

30MWh storage capacity

1.5MW of floating PV

800m buried penstock

GRP pipe

1000mm average dia

2500 litres per second

9 km/h

1. Pumped-Up Walpole

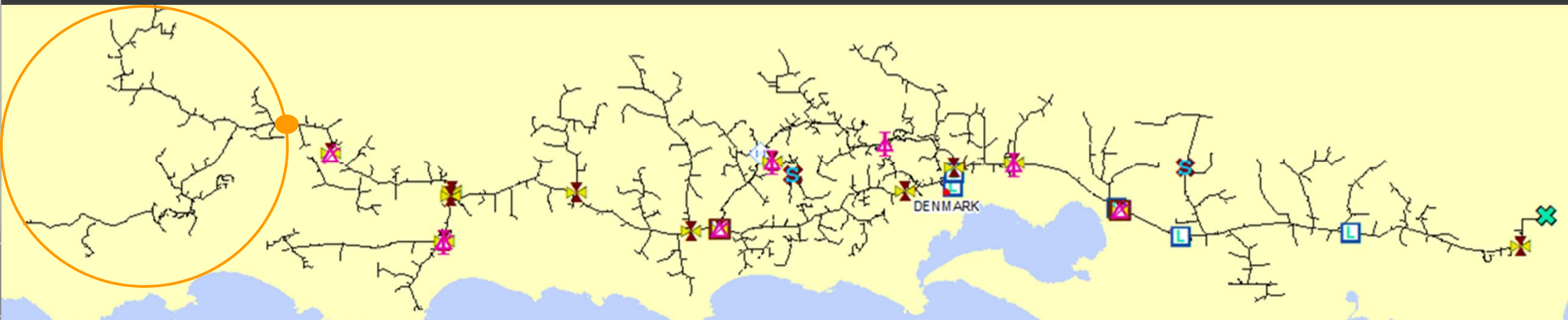
POWER RESEARCH & DEVELOPMENT

Connected 14km NE of Walpole

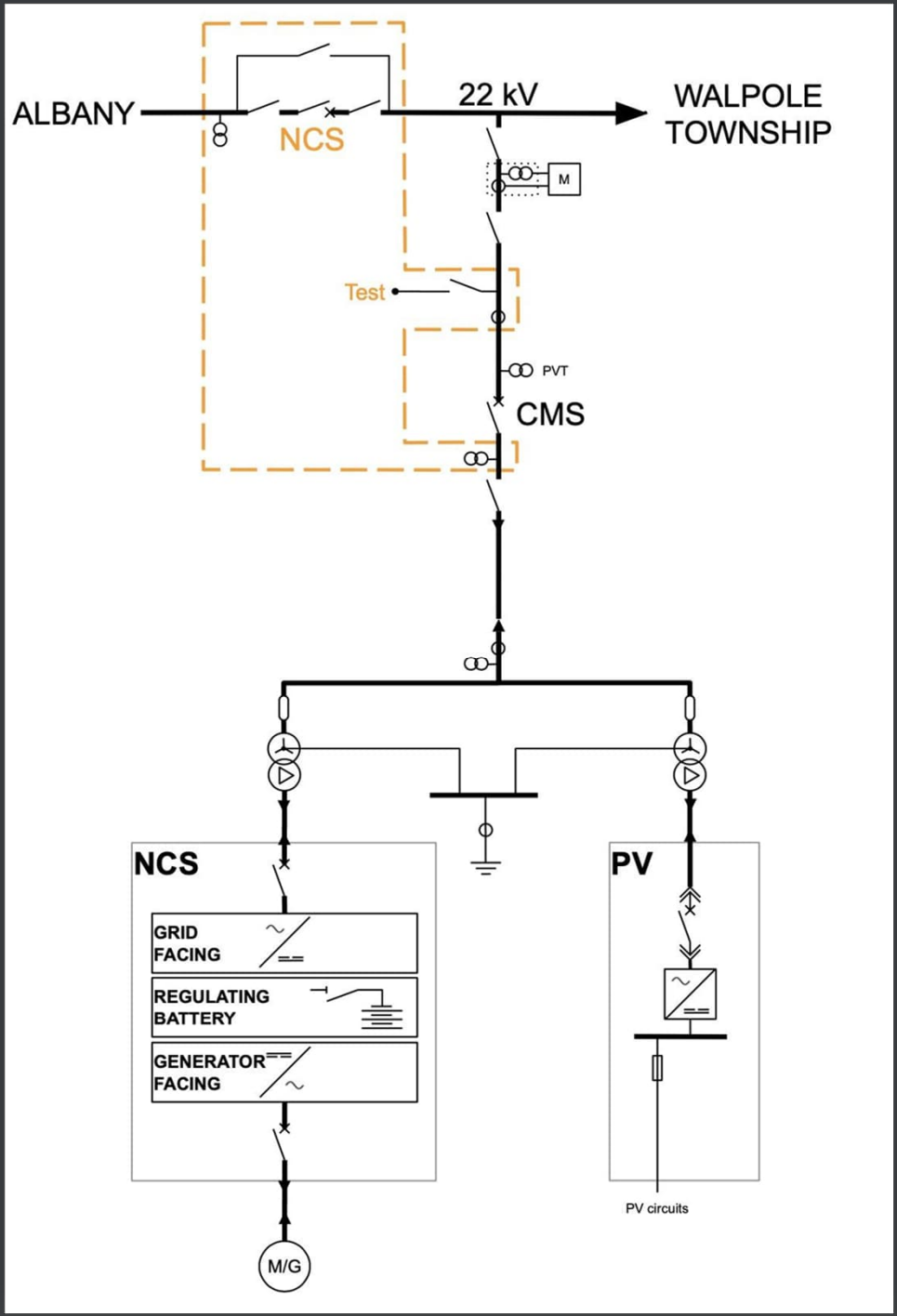
- 22kV distribution connection
- Visual simplicity by choice
- Standard regulated connection
  - Technical rules
  - Compliance

Edge of grid

- 125 km line, forests, SWER spurs
- 5 x voltage regulators
- Low fault currents:
  - 3 phase is 149 amps at 22kV
  - L-G is **119** amps
  - L-L is 74 amps



CHALLENGES AND SOLUTIONS



NETWORK CONTROL SERVICES

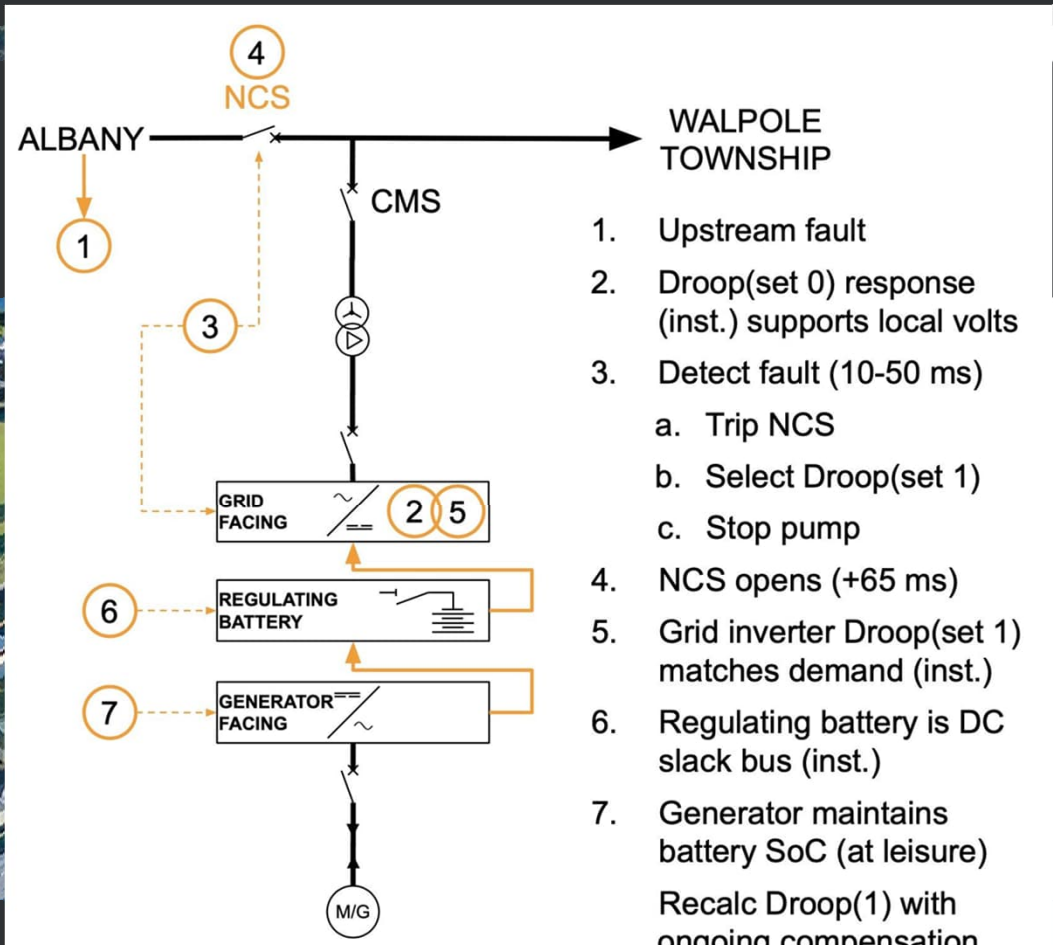
- Developed with Western Power
- Standby power to township:
  - Bumpless load acceptance (without breaking waveform)
  - 125 millisecond fault clearing
  - Long duration microgrid capable
  - Bumpless resynchronising and power transfer
  - Black-start capable
  - Interface with WP
- Discrete from connection systems
  - NCS protection, power and sensing
  - Integrated battery 1200kW for 15 min
  - Minimum NCS storage reserve

POWER QUALITY:

- Local voltage stability
  - ➢ Active VAR compensation
  - ➢ Passive VAR compensation (backup)
  - ➢ Conditional constraints mapping

- Maximise embedded PV
  - ➢ Bi-directional governing
  - ➢ PV runback

- Bumpless transition
- Stable microgrid
  - ➢ Regulating battery
  - ➢ Compositional control architecture
  - ➢ Pro-active governing and control
  - ➢ Critical fault clearing time



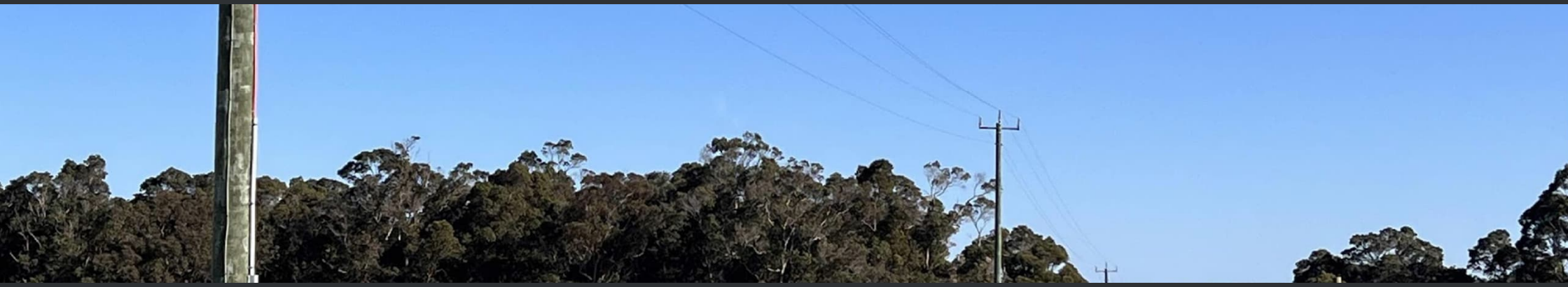
1. Upstream fault
2. Droop(set 0) response (inst.) supports local volts
3. Detect fault (10-50 ms)
   a. Trip NCS
   b. Select Droop(set 1)
   c. Stop pump
4. NCS opens (+65 ms)
5. Grid inverter Droop(set 1) matches demand (inst.)
6. Regulating battery is DC slack bus (inst.)
7. Generator maintains battery SoC (at leisure)

Recalc Droop(1) with ongoing compensation

WIDE AREA NETWORKING

- Anti-islanding ➢ Synchrophasor to Albany

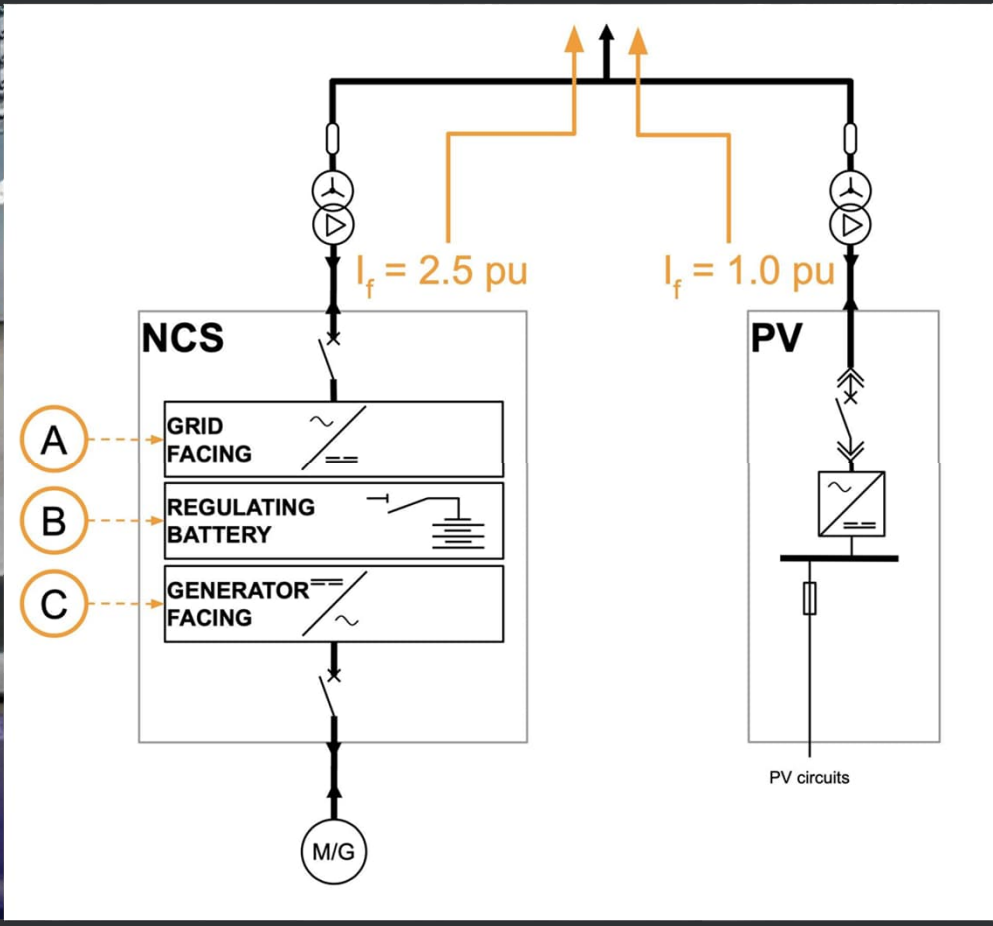
- Load sharing ➢ Compensated droop
- Multiple locations



- Remote synchronising ➢ Local NCS relay(s) - can be multiple
  ➢ Time insensitive logic
  ➢ Satellite clock synchronising

RESILIENCE & FLEXIBILITY:

- Existing protection selectivity
  - ➢ 3.25 pu fault current contribution
  - ➢ Microgrid only



- Failsafe
  - ➢ Compositional control architecture
  - ➢ Eliminate control risk
  - ➢ Backup protection

CAPITAL EFFICIENCY

Capital efficiency
before operating efficiency:

Fixed revenue **>** fixed costs

Variable revenue **>** variable costs

All technologies must compete

Some of our efficiencies are:

1. Mass producible components, deployable at scale
2. Distribution connected, latent infrastructure capacity
3. 100% energy efficient service - 65% operating cycle efficiency, plus 35% priming power solar PV
4. Fixed revenue optimised = NCS services, AEMO capacity market, green certificates, fixed retail services
5. Variable revenue is zero (or negative) marginal cost

FUNCTIONS	**Us**	BTM BESS	Community BESS	Utility BESS	Utility PHES	Smart Grids
Bumpless/instant (local)	✓	✓	✓			✓
100ms (local)	✓	✓	✓			✓
100ms (grid-wide)	✓	✓	✓	✓		✓
1-5 sec	✓	✓	✓	✓	✓	✓
1 hr	✓	✓	✓	✓	✓	✓
5-7 hr	✓	✓			✓	✓
Weeks	✓				✓	

QUESTIONS ARE WELCOME