Voltage management and inverters settings

West Australian experience/approaches

Nigel Wilmot – Senior Standards and Technology Engineer

About Western Power

2,700+
strong workforce

13 Community
Batteries

~793 battery
systems approved

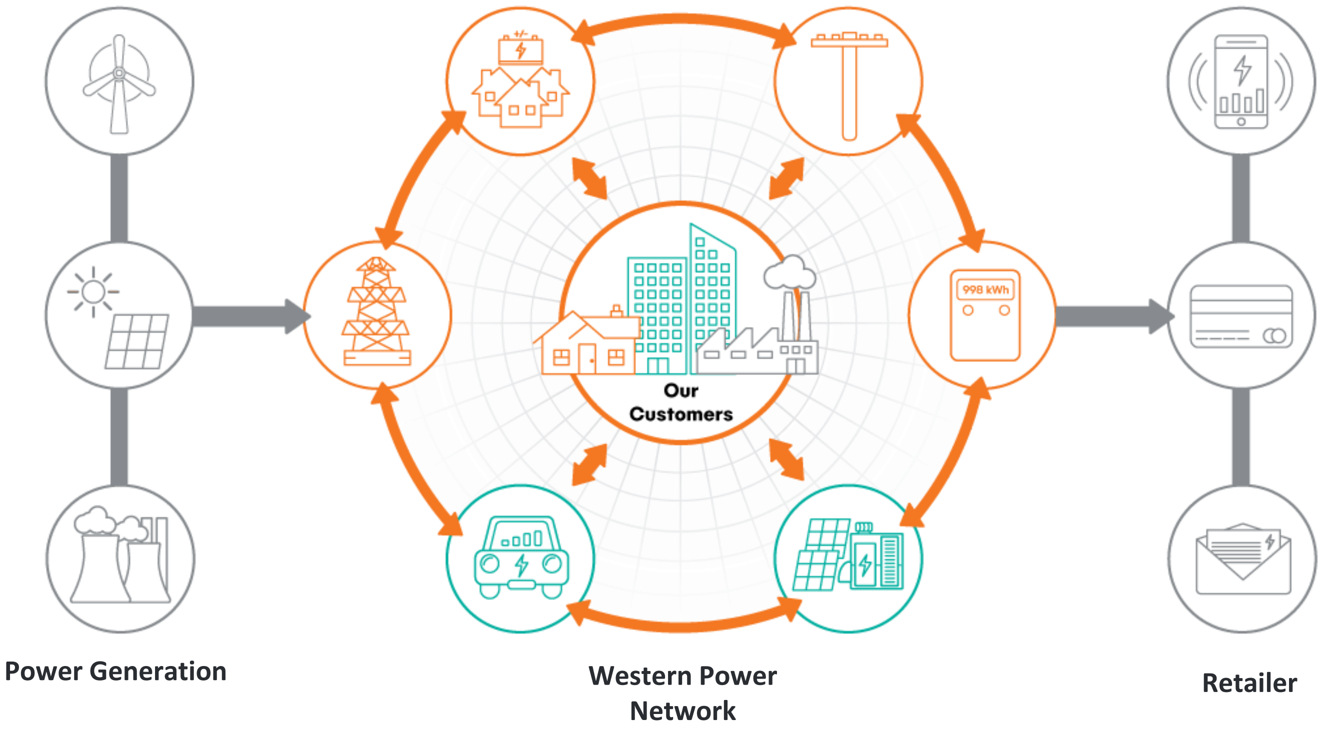
1GW+
rooftop solar
(~30% homes)

271,000
streetlights

2+ million
people connected

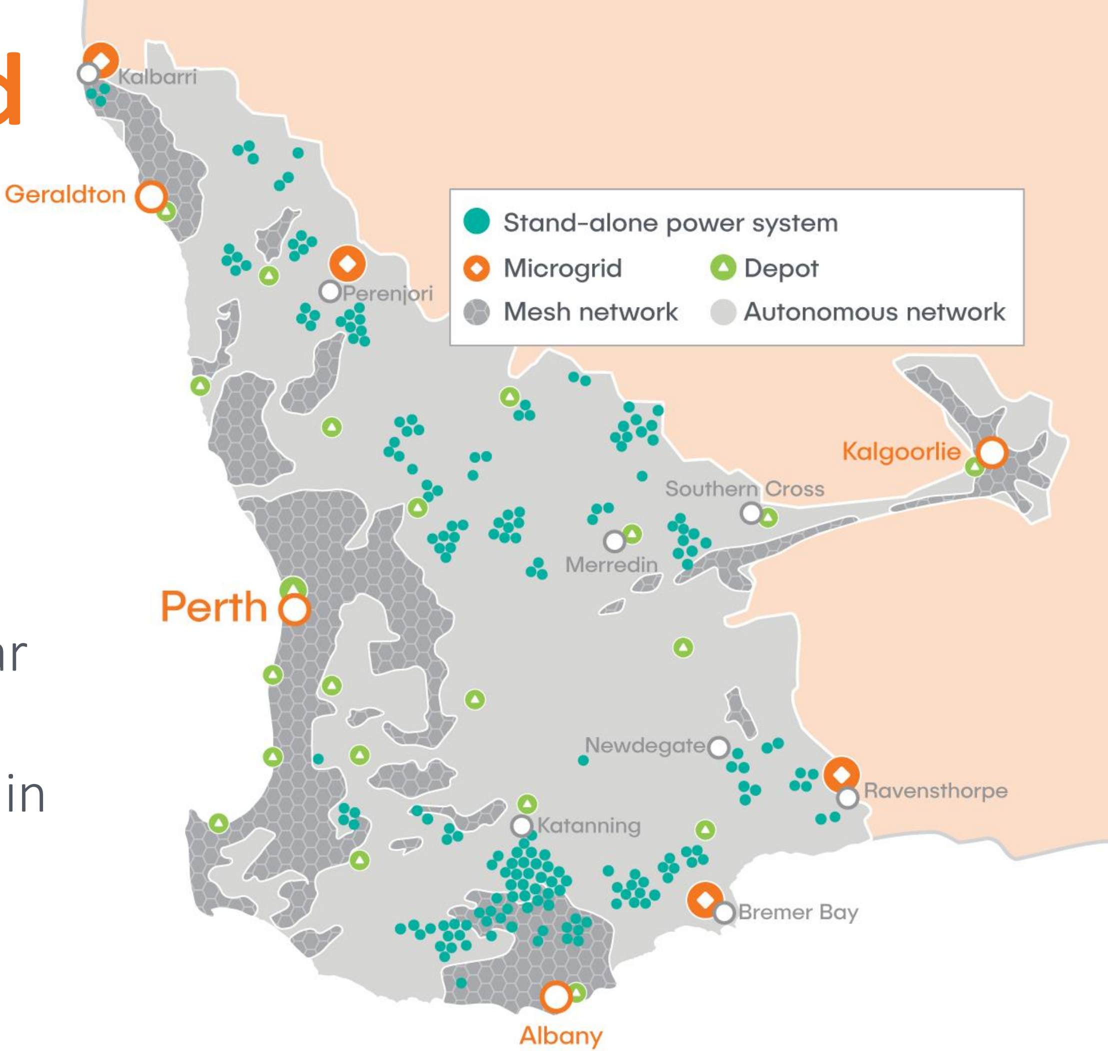
Figures correct as of January 2020

What we do


998 kWh
Our Customers
Power Generation
Western Power Network
Retailer

Future of the grid

- Autonomous grid includes SPS and microgrids as a cost effective alternative to traditional poles and wires.
- Mesh grid includes undergrounding to provide resilience; and to connect solar energy, electric vehicles and future emerging technologies in areas with higher energy demands.

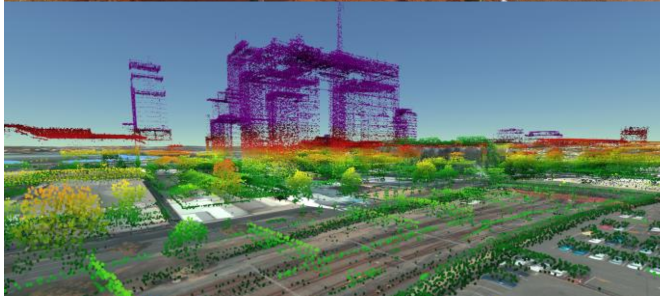


Grid innovations

- Microgrids
- Battery energy storage
- Stand-alone Power Systems (SPS)
- Community Batteries
- Advanced Metering Infrastructure (AMI)
- Demand management
- Preparing for electric vehicles
- Smoothing the load profile

Demand Management

Battery Energy Storage Solutions



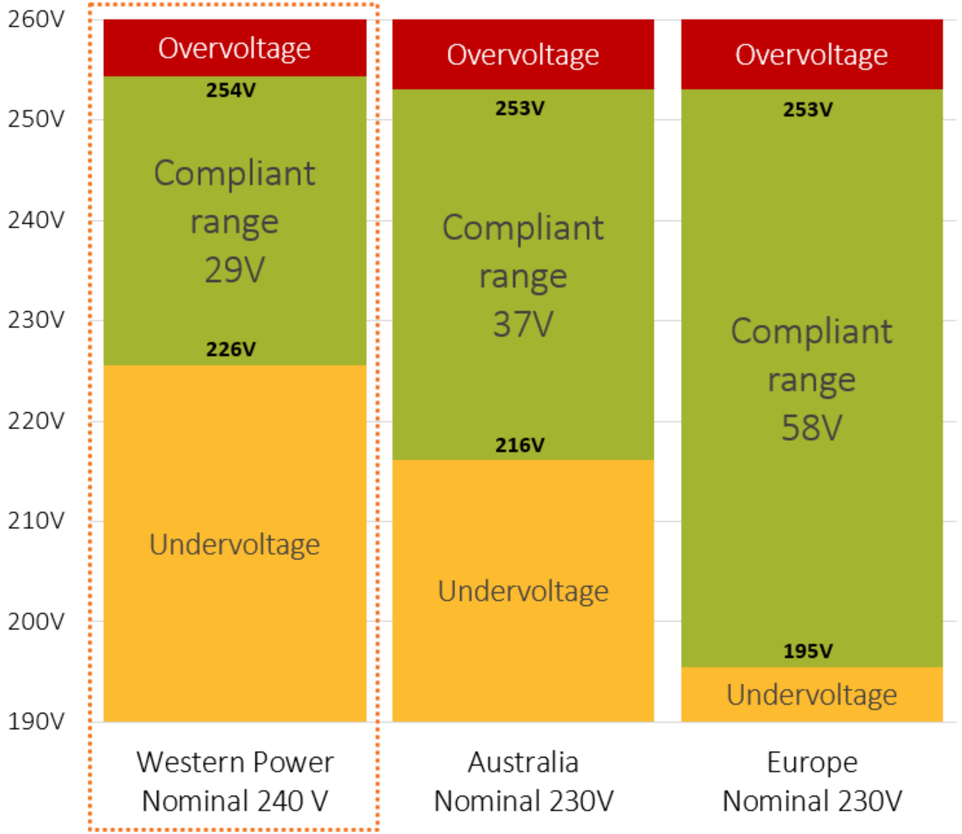
Digital Asset Management – Lidar

DER issues

- Over Voltage → constraining inverter output
- Minimum load → during daytime → 1.1 GW
- Largest generator is now DER at over 1.3 GW
- Network capacitance → central generation cannot absorb and challenges the voltage and frequency stability of the grid
- Load and DER is now connected by power electronic equipment/inverters more capacitive load than inductive.

Voltage obligations - Electricity Act 1945 [WA]

- Voltage must be constantly maintained within ±6% of nominal [240V]
- WA is out of step with rest of Australia and international arena
  - 230 V nominal
  - AU → +10% ,-6%

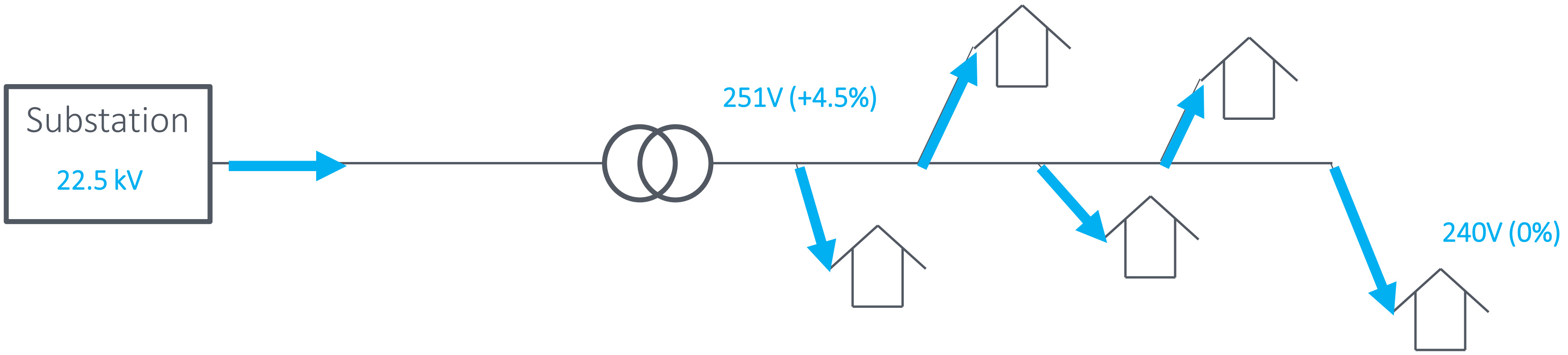


Safe voltage operating range

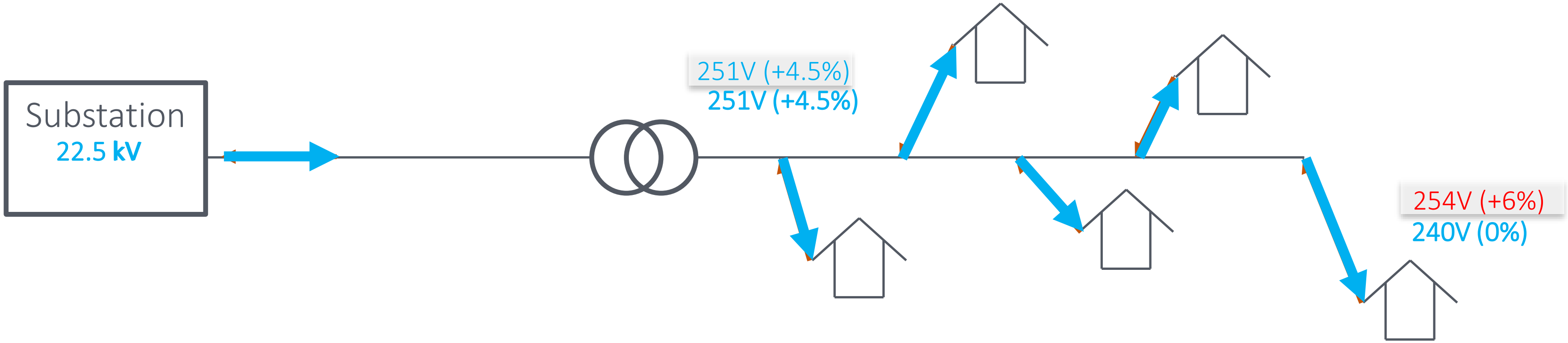
- Customer equipment
  - Manufactured for Australian voltage standard range for >20 years (216V to 254V→ i.e. 240 V +6%, -10% or 230 V +10%, -6%)
  - University testing showed customer equipment worked at
    - 206V (approx. -15% of 240V or -10% of 230V); and
    - 195 (approx. -20% of 240V or -15% of 230V)
- Larger range 216V to 254V enable voltage to be managed at lower median voltage (235 V to 245V) leading to more customer generation being connected

* expected outcome of WA DER roadmap change

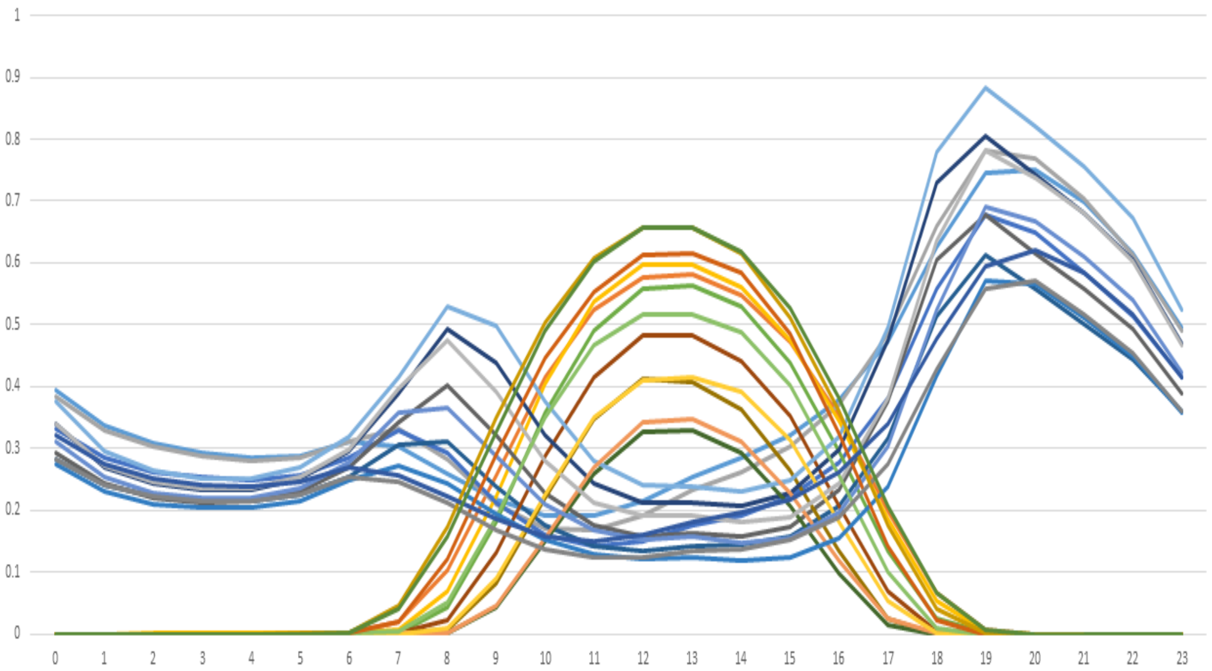
Voltage Example – One way power flow



Voltage Example – Two way power flow



Two way power flow - challenges



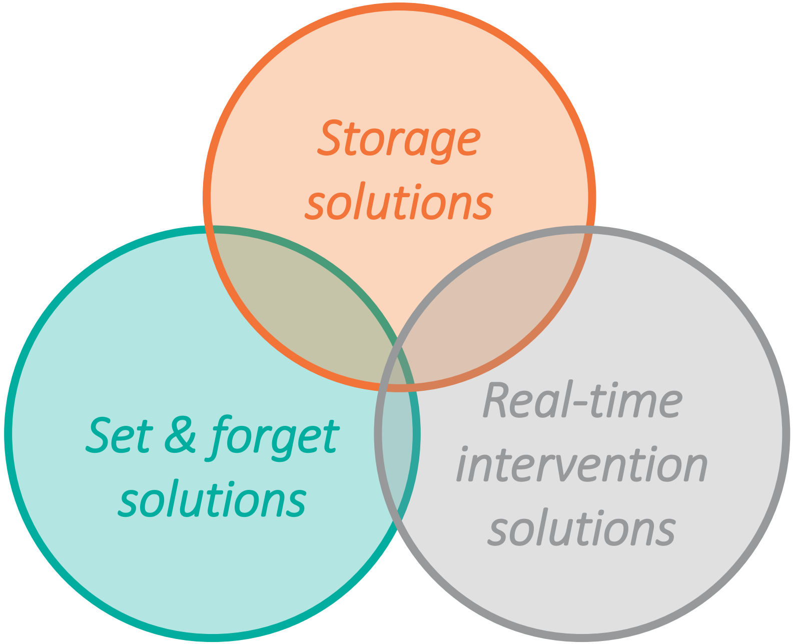
Increasing penetration of inverter energy systems (i.e. customer solar PV):

- Increasing trend of non-compliances of the high voltage limit (during high generation / low load conditions), and
- Potential voltage non-compliances of the low voltage limit (under high load conditions / low generation conditions).

DER management strategy

Network Voltage ↑

System Stability ↓



Customer Choice ↑

Optimised Investment ↑

SHORT-TERM

- Operational responses
- Trials of alternative solutions

MEDIUM-TERM

- Traditional responses – reactive support and augmentation
- Deploy mature alternate solutions; continue pilots

LONG-TERM

- Optimised mix of traditional and alternative solutions
- Active control

Set and forget solutions

Focus for today's presentation

- Voltage management
- Inverter Power Quality Response modes

Management of issue - now

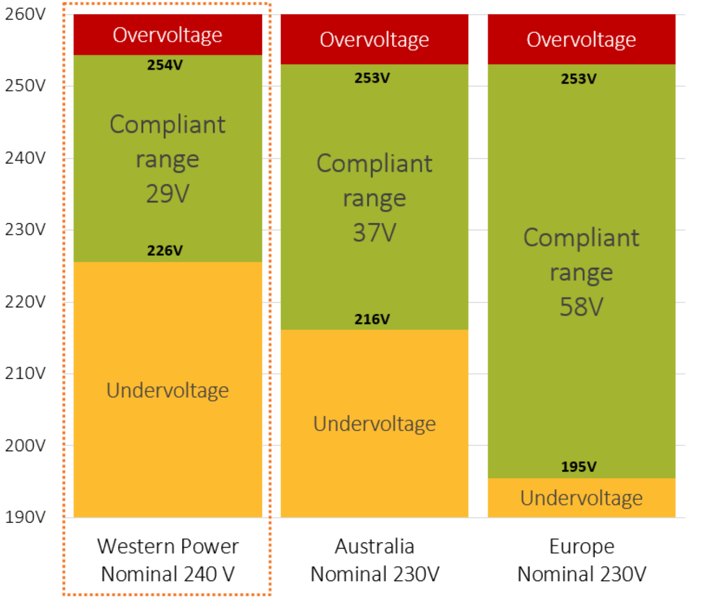
- WA Distributed Energy Resources (DER) roadmap looking to change legislation to remove voltage reference ±6% (approx. 2 year time frame)
- Ongoing management of automatic voltage control set points on:
  - Zone substation transformers, and
  - Distribution regulators.

→ Since 2015 up to 10V reduction across grid

- Annual LV power quality programs to address poor performing areas
- Annual external benchmarking of PQ monitoring with focus on voltage
  - Research into LV equipment tolerance of voltage shows < 226V not an issue (also <216V okay)
- Trials of voltage management technology
  - On load tap changing transformer
  - Community PowerBanks

…. and into the future

- AMI more data – target where real issues are
- Reactive upgrade → Customer fault reports identify potential safety and non-compliance issues
- Risk based and Probabilistic voltage planning methods to ensure new limits are met
- Investigating and using enabling technologies to connect more customer generation and manage network constraints including the voltage constraints.→ *DSO and others*



Inverter requirements

- AS/NZS 4777.2 202? → soon to be published
- New and refined withstand capabilities to enable improved grid stability e.g. UV ride-through, frequency withstand etc.
- Regional settings for PQ responses
- Additional testing for PQ responses and withstand capabilities

WA Regional PQ Settings

- Volt-watt (250V 100%, 260V,20%)
  - Slightly steeper slope
  - End point lowered from 265V due to cease power injection requirement

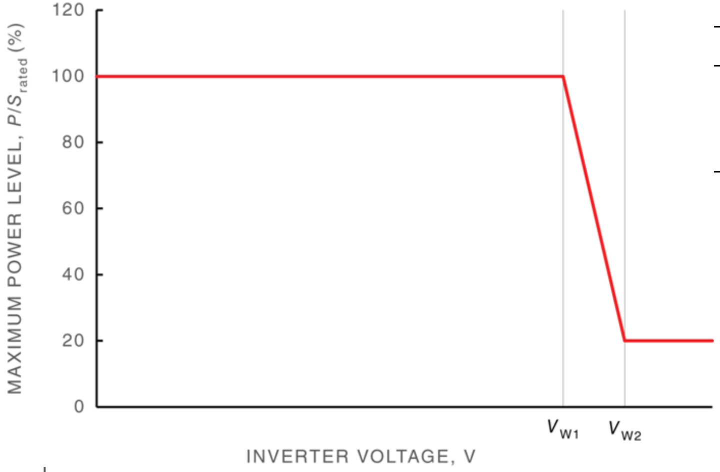


Table 3.6 Volt–watt response default set-point values

Region	Default value	V_{W1}	V_{W2}
Australia B	Voltage	250 V	260 V
	Inverter maximum active power output level (P) % of S_{rated}	100 %	20 %

Target for Customer expectation ➔ <1% of time system affected by this setting

WA Regional PQ Settings

- Volt-Var
  - Extended range
  - Priority over Volt-watt

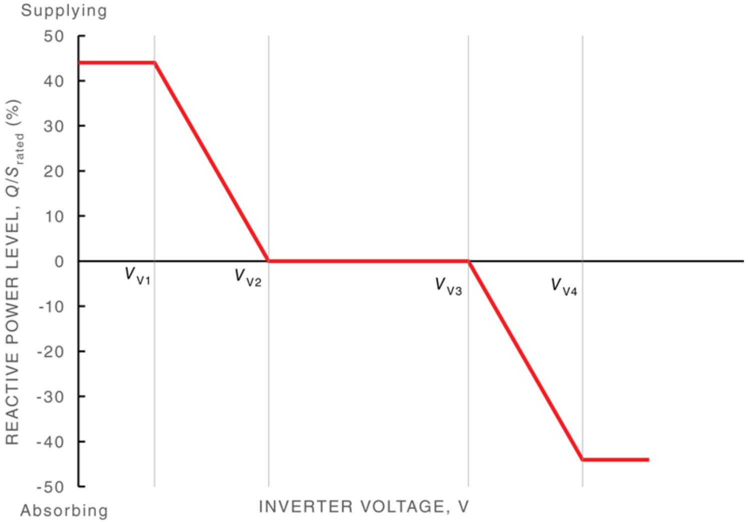
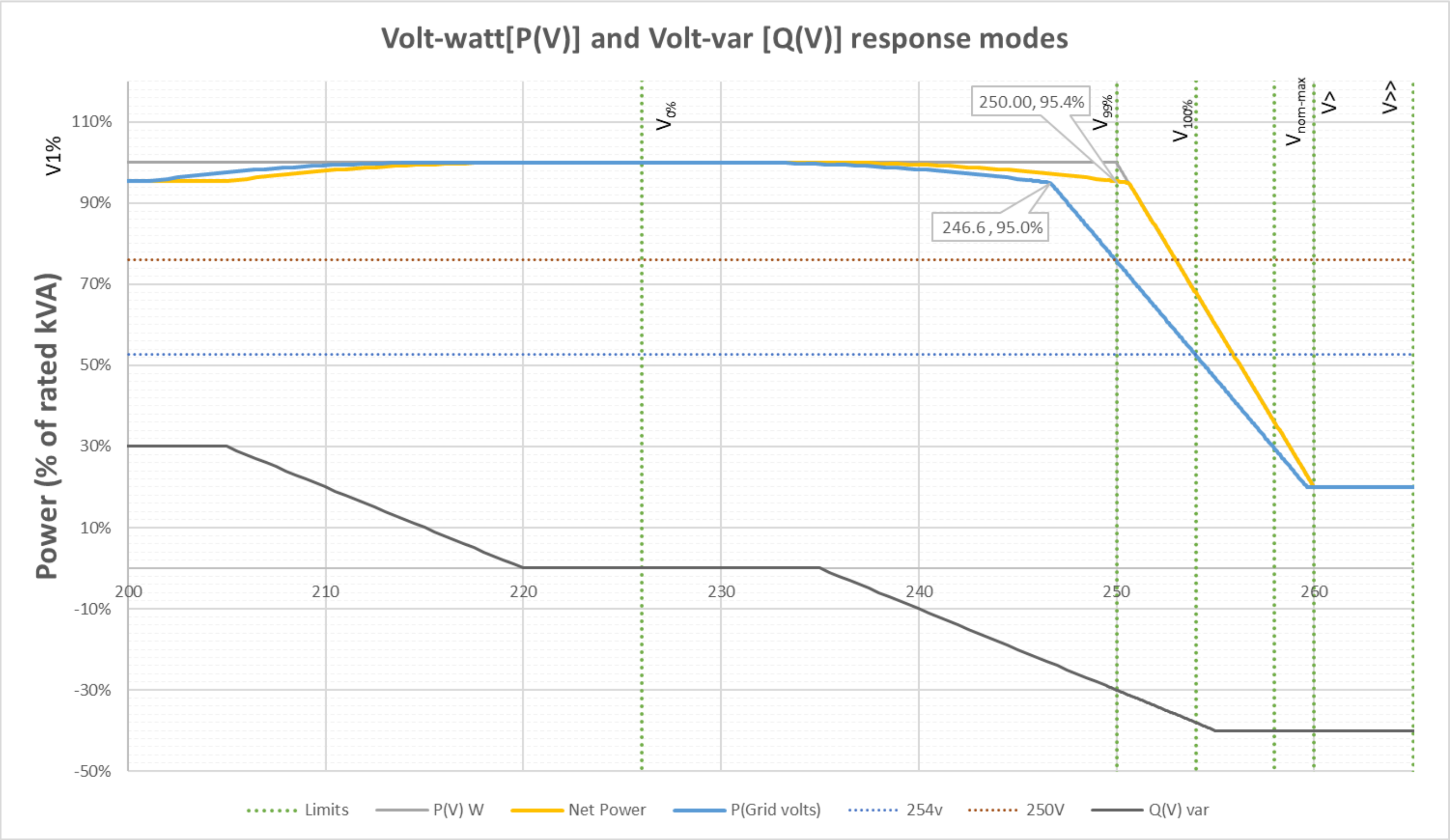


Table 3.7 Volt–var response set-point values

Region	Default value	V_{V1}	V_{V2}	V_{V3}	V_{V4}
Australia A	Voltage	207 V	220 V	240 V	258 V
	Inverter reactive power level (Q) % of S_{rated}	44 % supplying	0 %	0 %	60 % absorbing
Australia B	Voltage	205 V	220 V	235 V	255 V
	Inverter reactive power level (Q) % of S_{rated}	30% supplying	0 %	0 %	40 % absorbing

Target for Customer expectation → energy output minimally (<5%) affected during peak solar time (10am to 2pm)



- 2% V_{rise} consumer mains
- And inverter sub-main
- 25% self consumption

Rounding up

- Voltage range management → impacts flexibility of the grid to host DER
- Onus on Western Power (& other DNSPs) to meet compliance
- Onus on customers to operate systems to offset impact of the generation on the grid
- Western Power has coordinated the voltage strategy with DER settings to balance cost to all customers vs cost to individual DER customer

Discussion and questions

Perth office
363 Wellington Street
Perth, WA 6000
westernpower.com.au

Biography

Nigel has been working as an engineer for over 28 years. Initially at Murdoch University, in research focused on stand-alone & grid-connected inverter energy systems, then in developing national and international standards for these systems. Over the last 12 years he has been working at Western Power and he has been key in influencing Western Power approach to management and connection of these small scale renewable energy systems into the grid. This has been through his work with the AS/NZS 4777 standards develop, the Western Power connection requirements as well as responsibility for PQ and voltage strategies work. In 2020, Nigel was recipient for the “2020 National Meritorious Contribution” award from Standards Australia and has been awarded status as a Fellow of the Institute of Engineers Australia.

2/12/2020