



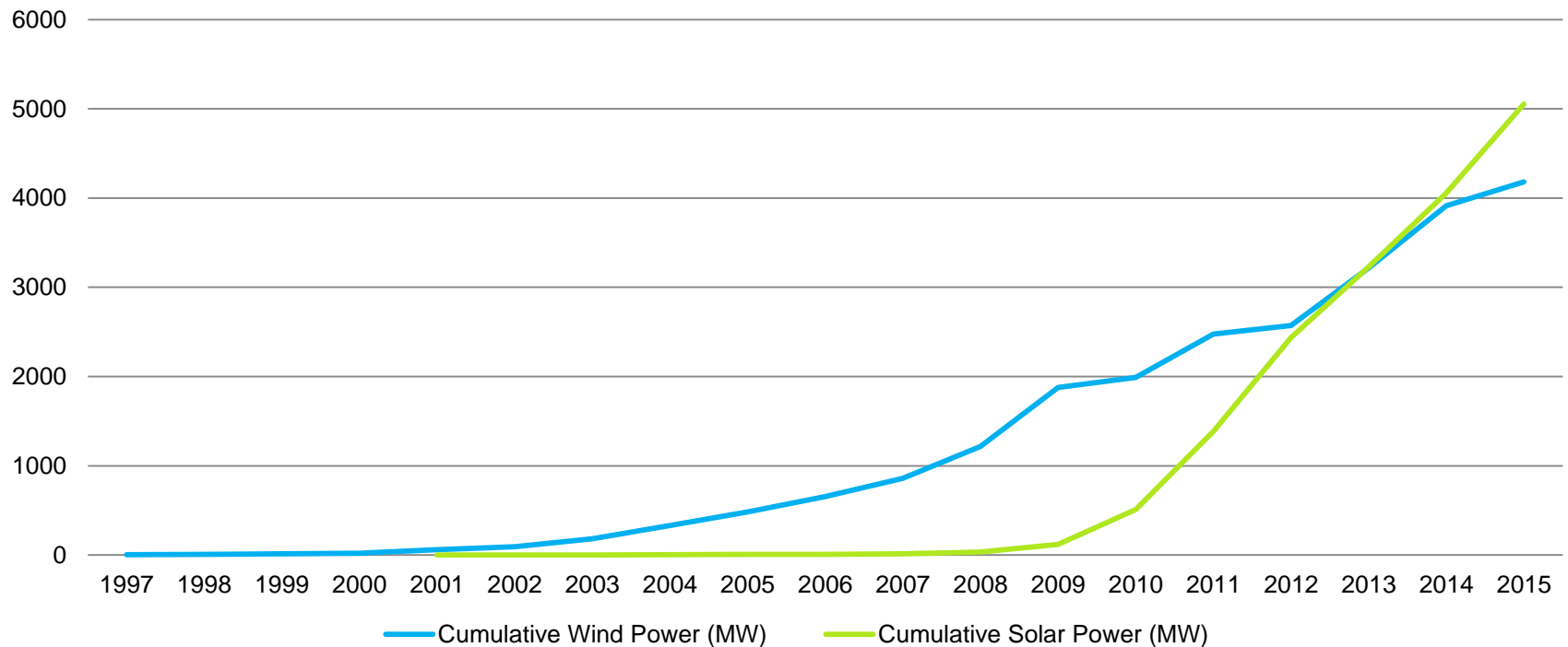
IMPACTS OF HIGH LEVELS OF RENEWABLES AND STORAGE ON THE LOCAL GRID AND RETAIL MARKETS

ActewAGL

for you

INSTALLED PV GENERATION CAPACITY BY STATE/TERRITORY

Cumulative Wind and Solar Power in Australia

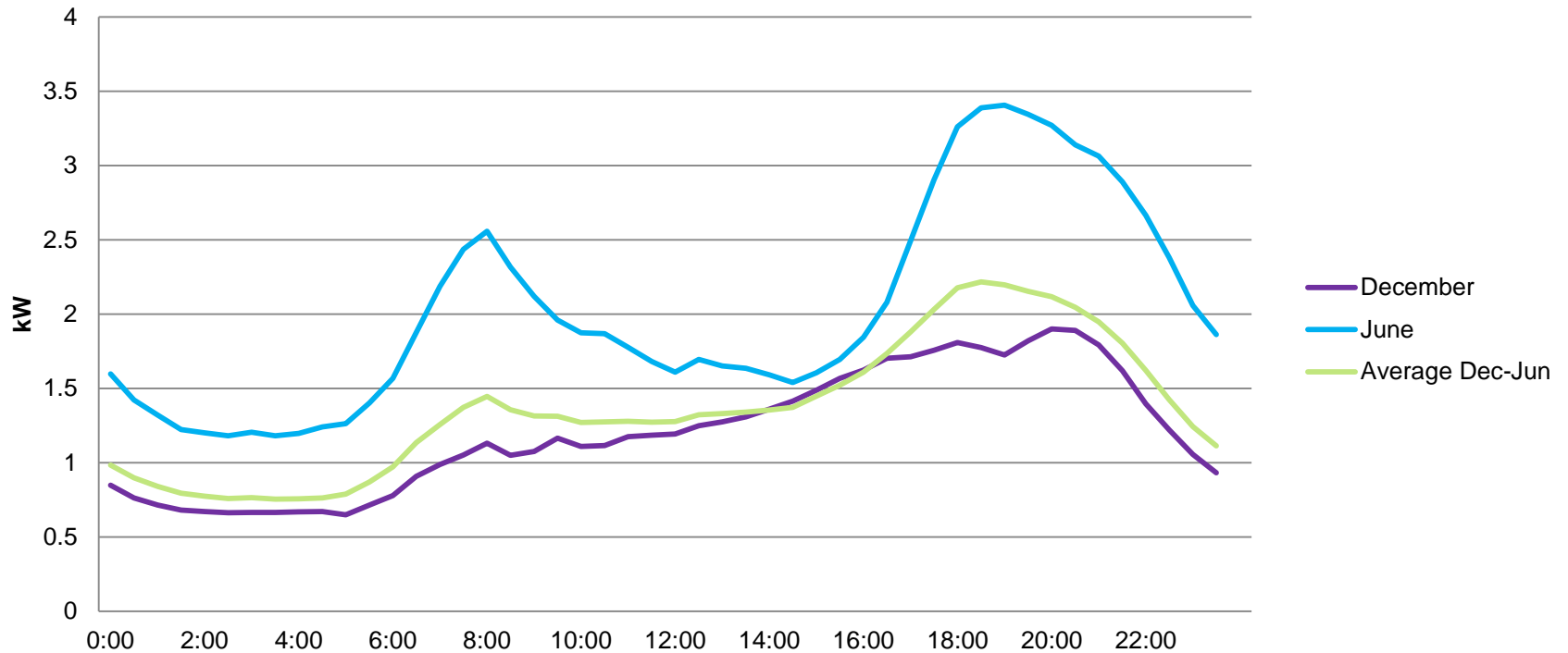


Solar data from Australian PV Institute (APVI) Solar Map, funded by the Australian Renewable Energy Agency, accessed from pv-map.apvi.org.au on 28 November 2016

Wind data from http://ramblingsdc.net/Australia/WindPower.html#Chronology_of_wind_farm_construction, accessed on 28 November 2016

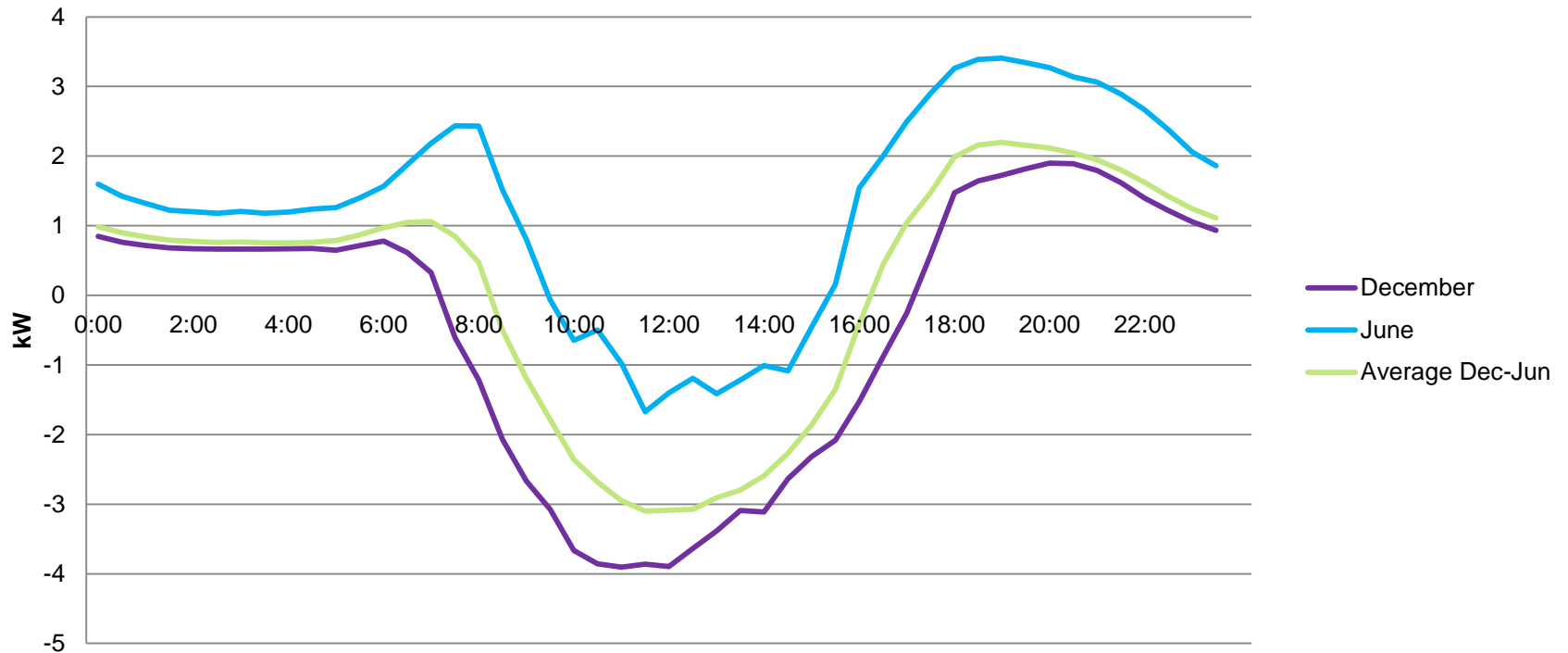
RESIDENTIAL CONSUMPTION

Net Residential Consumption, No Generation



RESIDENTIAL CONSUMPTION

Net Residential Consumption, 5kW PV Generation

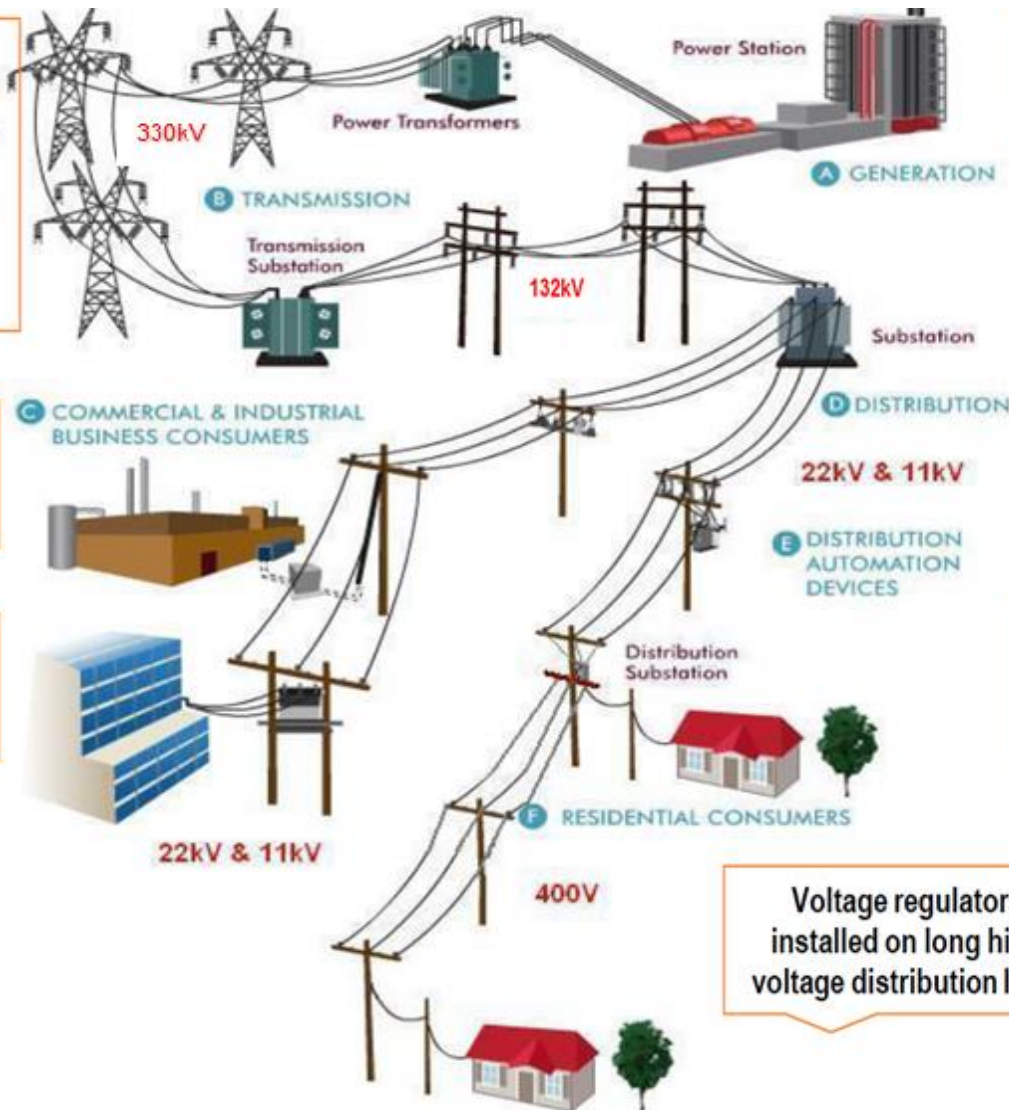


EXISTING VOLTAGE CONTROL SCHEMES ARE NO LONGER ADEQUATE

Generator step-up transformer, transmission substation transformer and zone substation transformer are fitted with on-load tap changing facility

Shunt reactors to compensate for long cable circuits

Some large customers also install power factor correction capacitors



Generator can generate or absorb reactive power

Power factor correction capacitors are installed at transmission substation, zone substation and (in some cases) high voltage distribution lines

Distribution transformer is fitted with off-load tap changing facility

Voltage regulators installed on long high voltage distribution lines

NETWORK IMPACT OF RESIDENTIAL ROOF-TOP SOLAR

- Localised voltage rise (steady state)
- Phase imbalance
- Rapid Voltage fluctuations (flickers caused by cloud transients)
- DC and harmonic injection
- Reverse power flow
- Malfunction of voltage control equipment
- Equipment overload
- System security

VOLTAGE CONTROL STRATEGIES IN RESPONSE TO HIGH PV PENETRATION

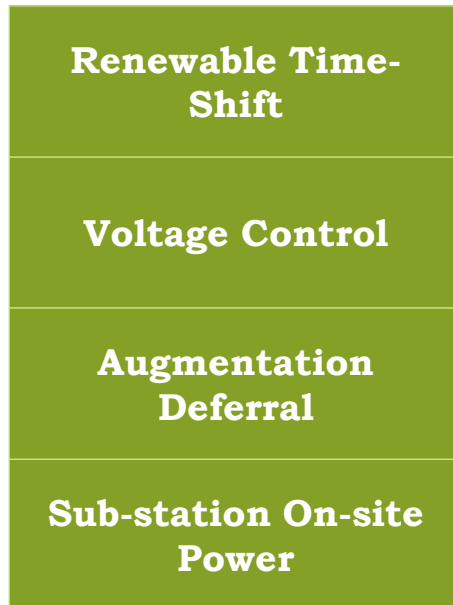
- Lower delivered voltage
- Power quality data from smart meters
- Improve phase balance on the three phases
- Improve existing zone substation voltage regulation
- Implementation of LV voltage regulation technologies
- **Stabilise PV outputs using storage technologies**
- Active distribution network management

ENERGY STORAGE TECHNOLOGIES CAN SOAK UP THE EXCESS GENERATION AND REDUCE THE NETWORK IMPACT OF PV

- Over voltage and voltage flickers caused by PV can be addressed by energy storage technologies e.g. storage battery
- Increasing internal energy consumption during maximum PV generation could be a cost effective way to deal with OV. This is made possible by the use of Home Energy Management System (HEMS) and controllable load such as water and space heating.

POTENTIAL STORAGE APPLICATIONS WITHIN NETWORK

High Potential Storage Applications



Low Potential Storage Applications



POTENTIAL NEW MARKET PARTICIPANTS

- Smart Meter Data Provider
 - Provision of real time data streams [5 minute instantaneous V,I and PF]
- Aggregators
 - Provision of Automated Demand Response and other Ancillary Services
- Embedded Network Operators
- Microgrid & Building Services Operators
- Virtual Power Plant Operators

❖ **Aggregation of benefits is the key.**