Modeling and Analysis of Spot Market Volatility Following the Large Scale Deployment of Distributed Generation onto Australia's National Electricity Market

By

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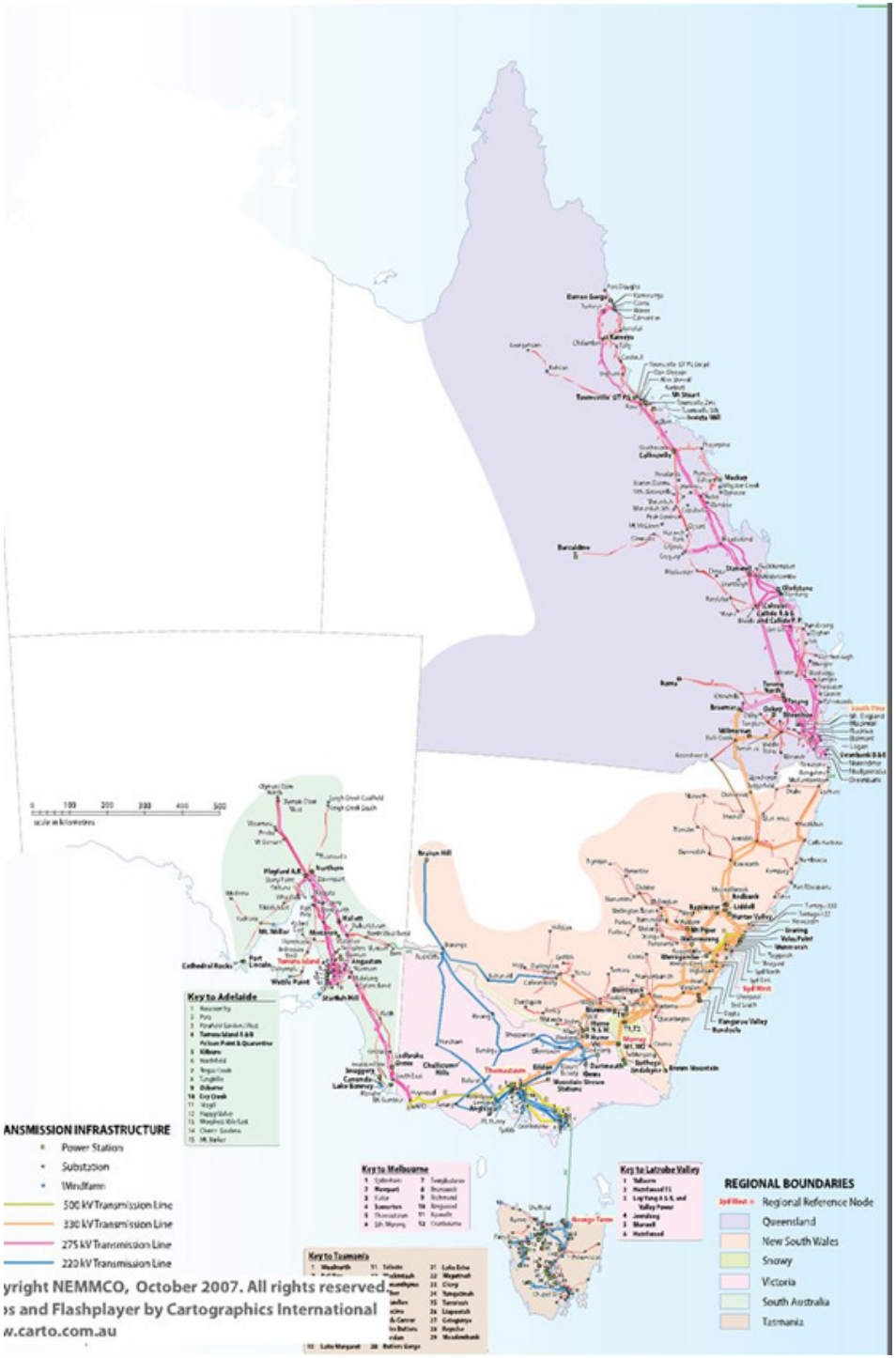
Outline

- Overview: Why DG?
- Australia's Electricity Market
- Modelling Framework
- Distributed Generation Deployment
- Results

Overview

- What could Distributed Generation do for Australia's National Electricity Market?
- Australia spends a significant amount on transmission and distribution charges to deliver our electricity
  - At around 45% of retail tariff
- Australia's Emissions are one of the highest per capita.
- What are the other benefits of deploying DG?



Source: NEMMCO Statement of Opportunities 2007

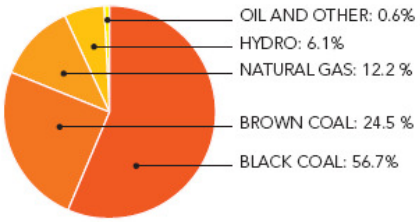
The ~41 GW supply-side covers all of eastern Australia:

- Queensland 10,400MW
- New South Wales 12,300MW
- Snowy Mountains 3,700MW
- Victoria 8,600MW
- South Australia 3,500MW
- Tasmania 2,500MW

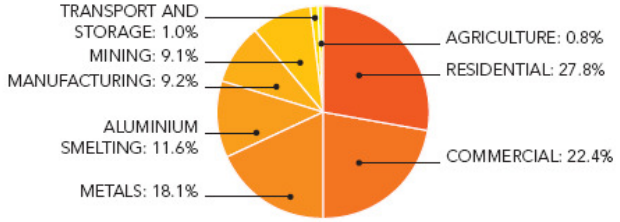
The demand-side:

- Aggregate demand (simultaneous) 32,000MW
- Aggregate energy 205,000GWh
- CO2 emissions at approx 180Mt, about 35% of the national total

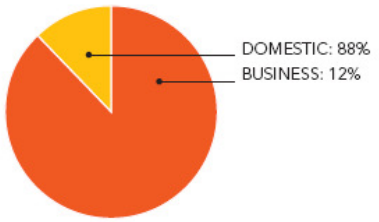
GENERATION BY FUEL TYPE



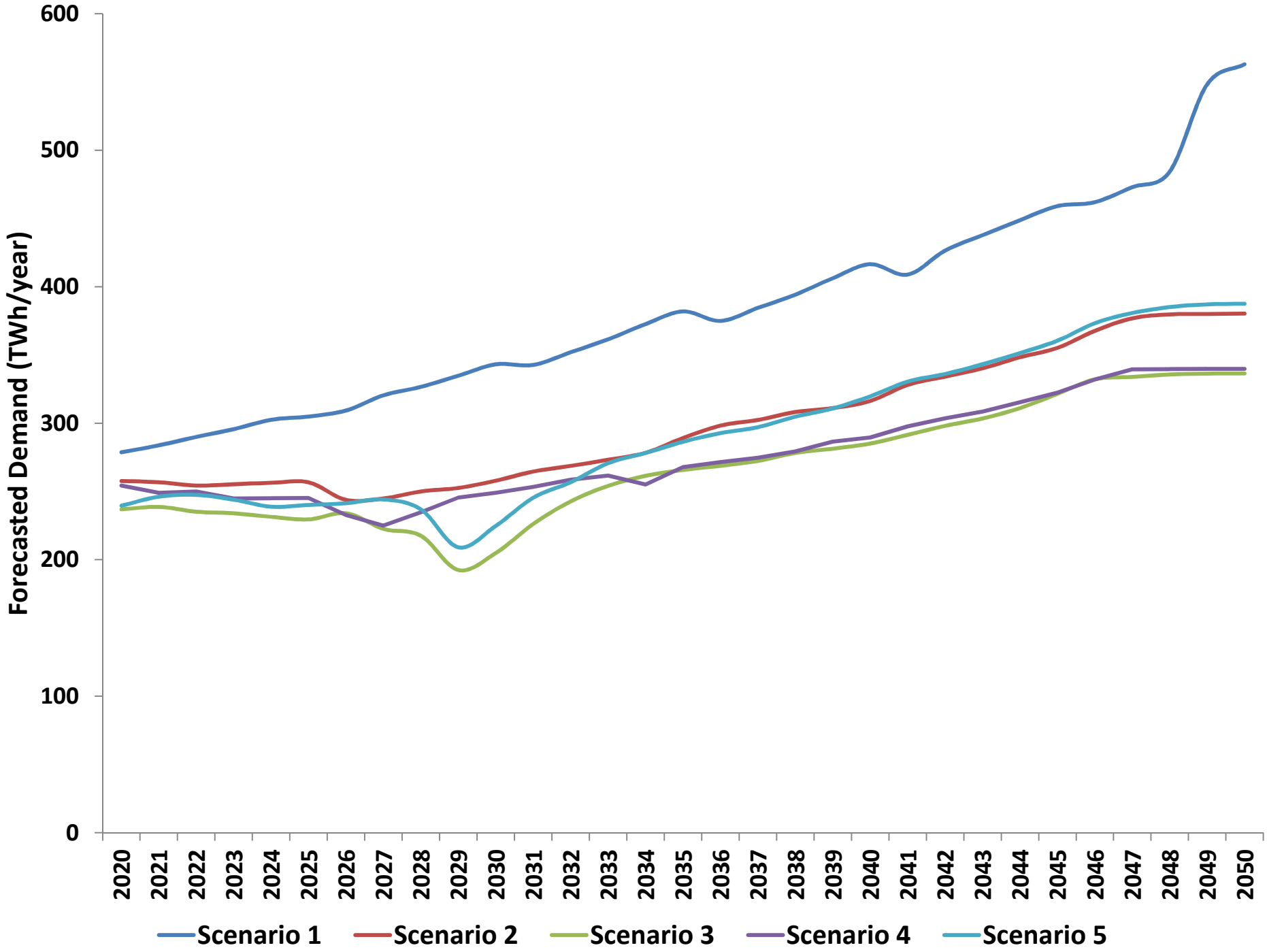
ELECTRICITY CONSUMPTION BY SECTOR

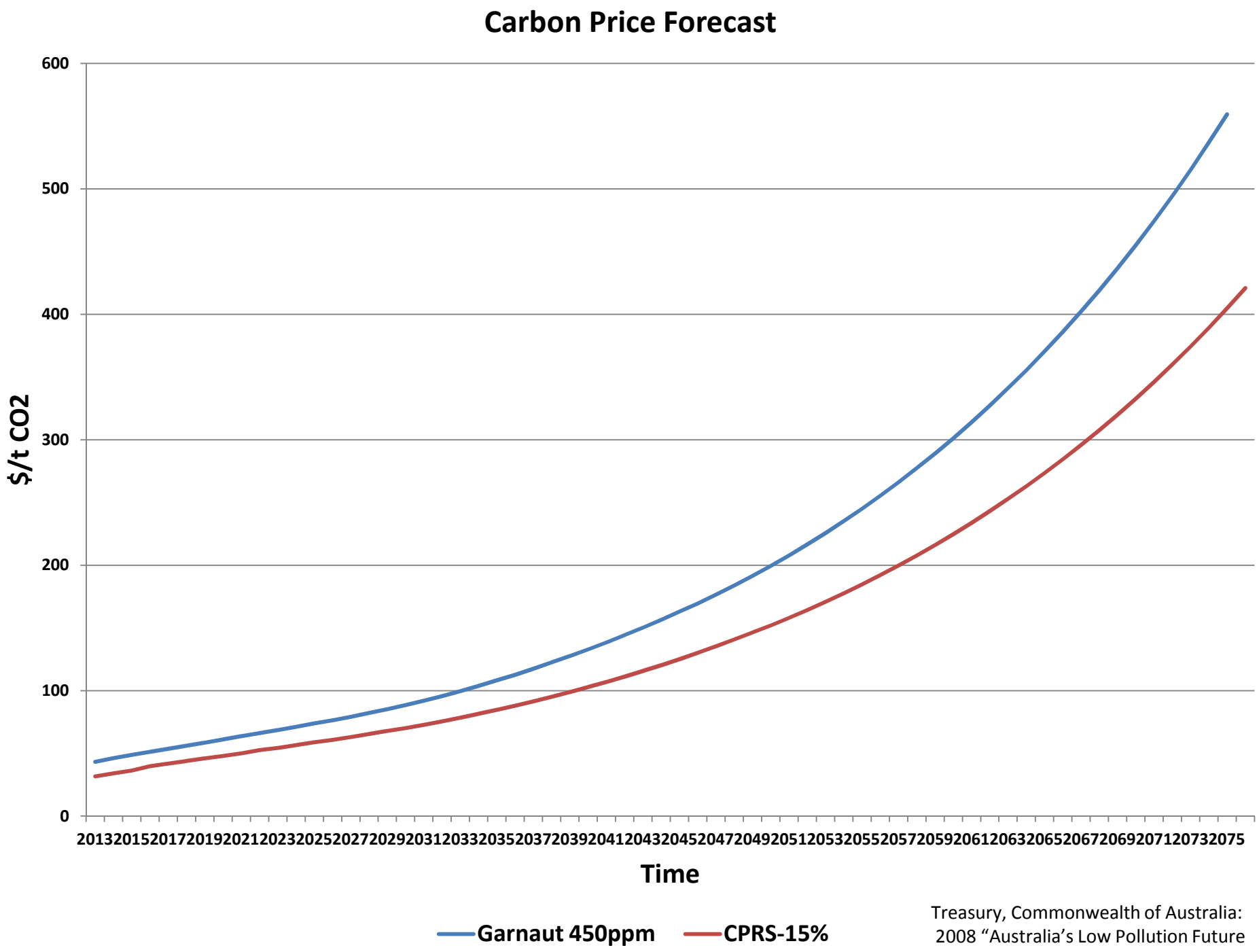


NUMBER OF CUSTOMERS BY SECTOR



Source: An Introduction to Australia's National Electricity Market, July 2009
Australian Energy Market Operator (AEMO)


Forecasted Demand (TWh/year)
600
500
400
300
200
100
0
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5



Treasury, Commonwealth of Australia:
2008 "Australia's Low Pollution Future

So Why is Price Important?

- Structurally for a market like the NEM to maintain high and volatile prices there has to be something wrong.
  - Installed capacity?
  - Uncertainty of optimal entry timing?
  - Insufficient investment in transmission?
- High spot prices place upward pressure on retail tariffs.
- Volatile prices pose serious risks to retailers who are not also generators which reduce competition for consumers.

Modelling

We consider 10 distinct years in a 40 year planning horizon out to 2050. The following five policy frameworks were modelled as follows:

- **Scenario 1, Business-As-Usual (BAU) case with no carbon trading:** in which carbon pricing is not implemented. Load growth is met by significant investment in large centralised generation assets such as base load coal, combined cycle gas turbines (CCGT), solar thermal, geothermal (hot fractured rocks) and wind turbines.
- **Scenario 2, CPRS -15% no DG:** The CPRS is introduced in combination with the renewable energy target to reach an overall reduction of emissions by 15% below 2000 levels. The price of emissions permits reaches approximately \$50 t/CO_2 in 2020. Demand growth is reduced compared to the reference case given the increase in energy costs following the implementation of the CPRS. Increased renewable generation asset deployment is observed in this scenario compared to the BAU reference case.
- **Scenario 3, Garnaut 450ppm no DG:** The introduction of the CPRS with a deeper emissions abatement pathway is implemented to achieve an overall reduction of emissions of 25% below 2000 levels. The emissions permit price reaches around\$61 t/CO_2 in 2020 which will place more pressure to achieve further energy efficiency and lower emissions technology deployment across the NEM.
- **Scenario 4, CPRS -15% with DG:** Following the introduction of the CPRS, emissions permit prices stimulate the deployment of small scale DG technologies. The roll out of small scale decentralised generation will allow for additional cuts in emissions than the corresponding CPRS -15% case study.
- **Scenario 5, Garnaut 450ppm with DG:** With the implementation of deeper cuts to emissions following the introduction of a 25% target via the CPRS, higher permit prices stimulate a variety of alternative DG options for deployment across the NEM. Furthermore, increased pressure from permit prices reduces demand, resulting in a decreased reliance over time on centralised higher emitting generation types.

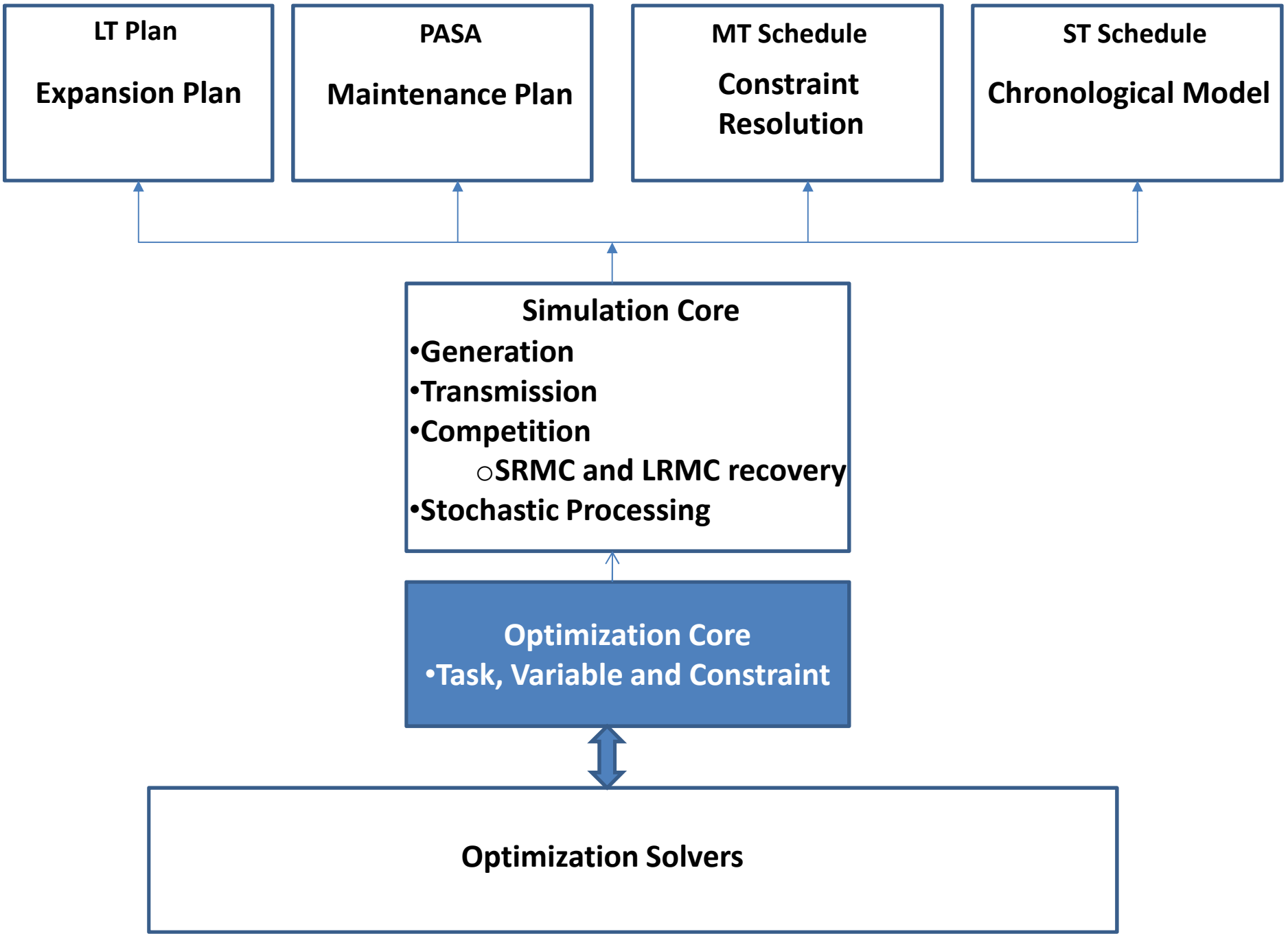
Energy Sector Model
(Developed by CSIRO)

A Markal type top down modelling framework of Australia's energy system which forecasts:

- Generation investment (Both Central and Distributed technology types)
- Demand forecasts
- Fuel usage
- Transportation sector

Plexos Simulates

- Optimal dispatch of generators across the NEM.
- Optimal bid stack formulation for each station for Short Run and Long Run Marginal Cost (SRMC and LRMC) recovery.
- Merit order of dispatch formulated based on bid stack.
- Physical operating characteristics of each generating unit
- Portfolio optimisation and emissions profiles
- Transmission and Interconnector flows.


LT Plan
Expansion Plan
PASA
Maintenance Plan
MT Schedule
Constraint Resolution
ST Schedule
Chronological Model
Simulation Core
•Generation
•Transmission
•Competition
○SRMC and LRMC recovery
•Stochastic Processing
Optimization Core
•Task, Variable and Constraint
Optimization Solvers

Distributed Generation

- The roll out of Distributed Generation (DG) could have a significant impact on the NEM.
- Deployment of rapid start/ramp up plant could significantly reduce extreme price spikes (especially at peak time)
- Recent study suggests a reduction in volatility and average prices

DG Technology Types

- Gas combined cycle w. CHP 30 MW
- Gas microturbine w. CHP 60 kW
- Gas reciprocating engine 5 MW, 500 kW and 5 kW
- Gas reciprocating engine w. CHP 1 MW and 500 kW
- Biomass steam w. CHP 30 MW
- Solar PV 40 kW and 1kW
- Diesel engine 500 kW
- Wind turbine 10 kW and 1kW
- Biogas/landfill gas reciprocating engine 500 kW
- Gas fuel cell w. CHP 2 kW
- Gas microturbine w. CCHP 60 kW
- Gas reciprocating engine w. CCHP 5 MW and 500 kW

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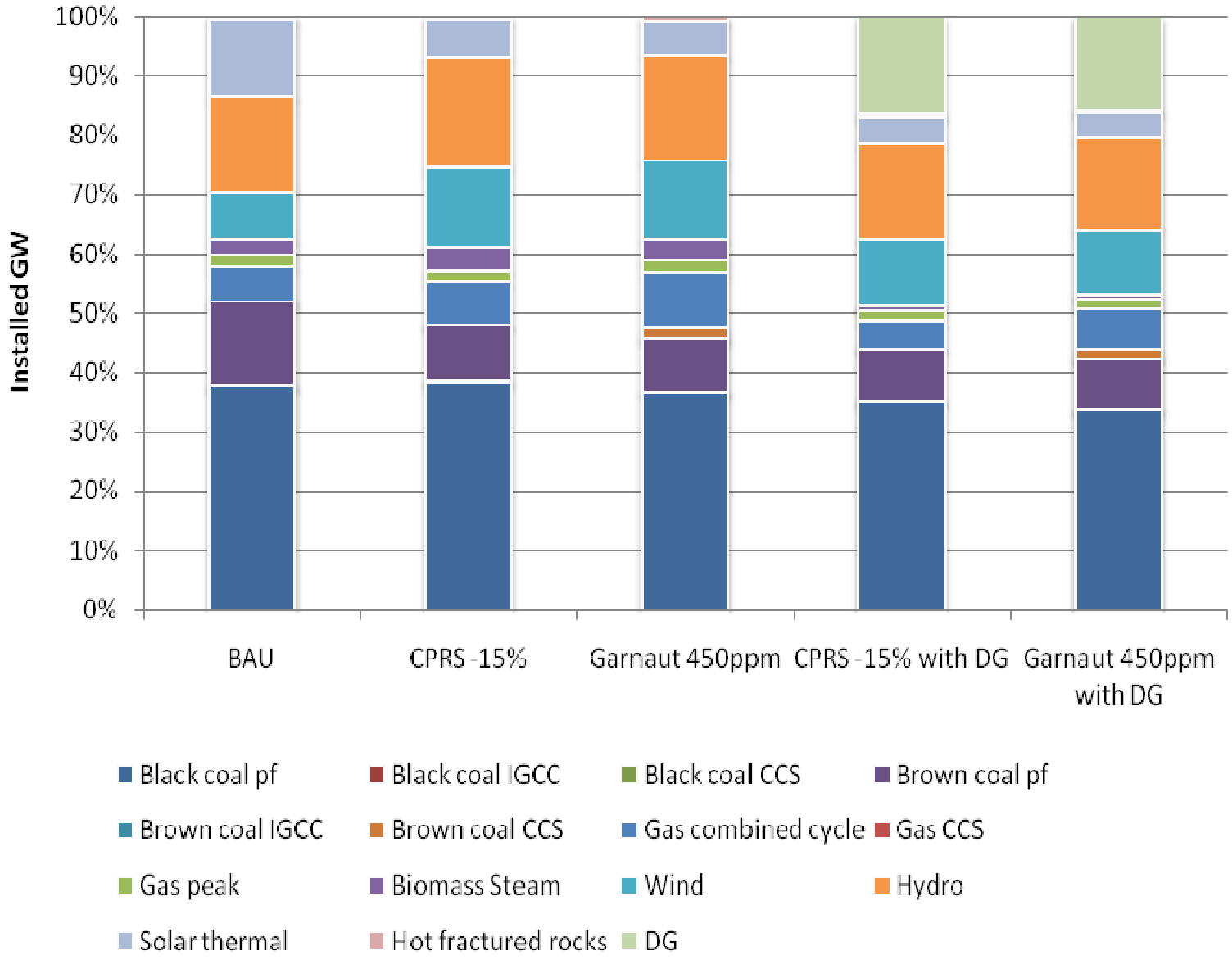
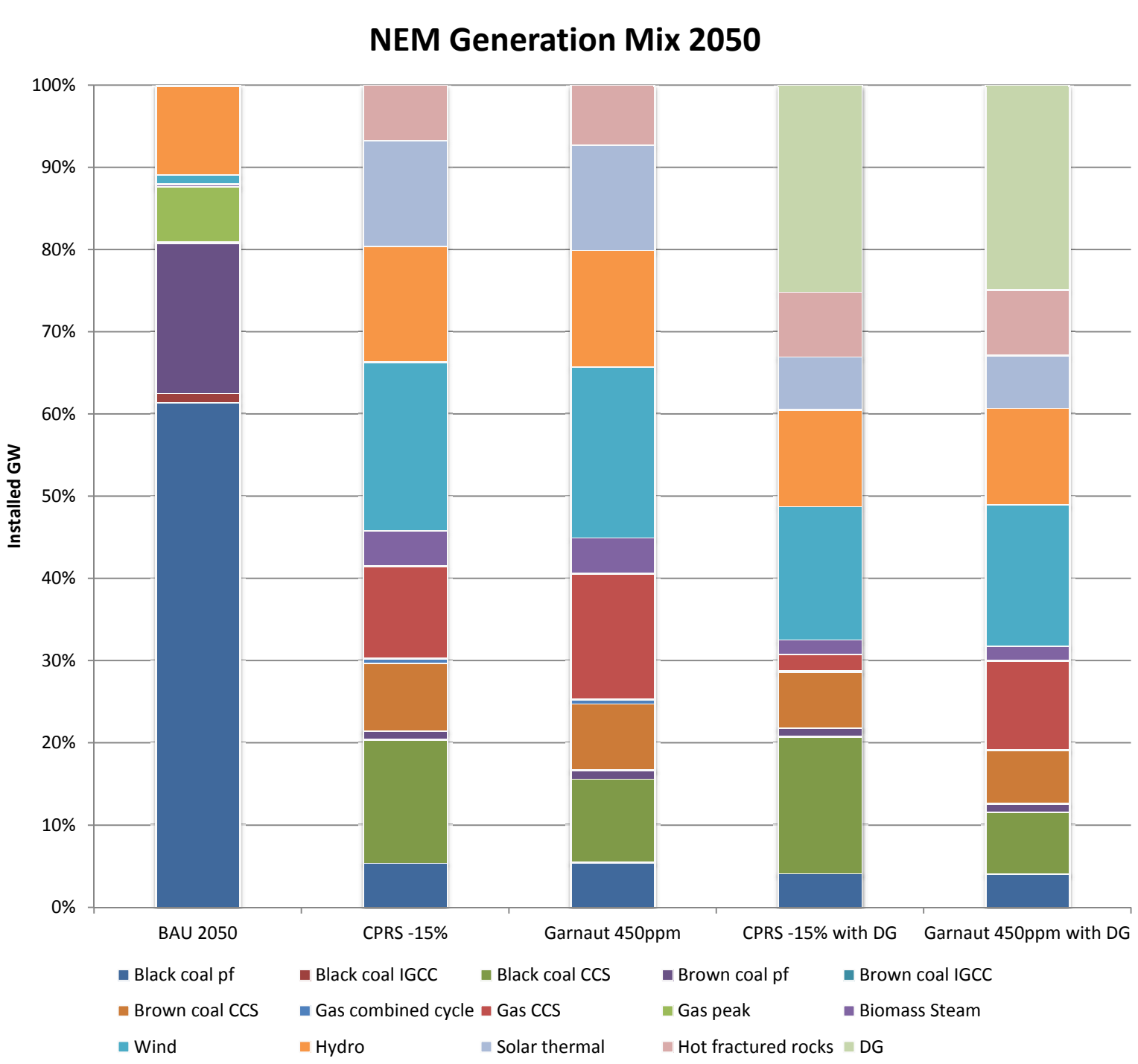
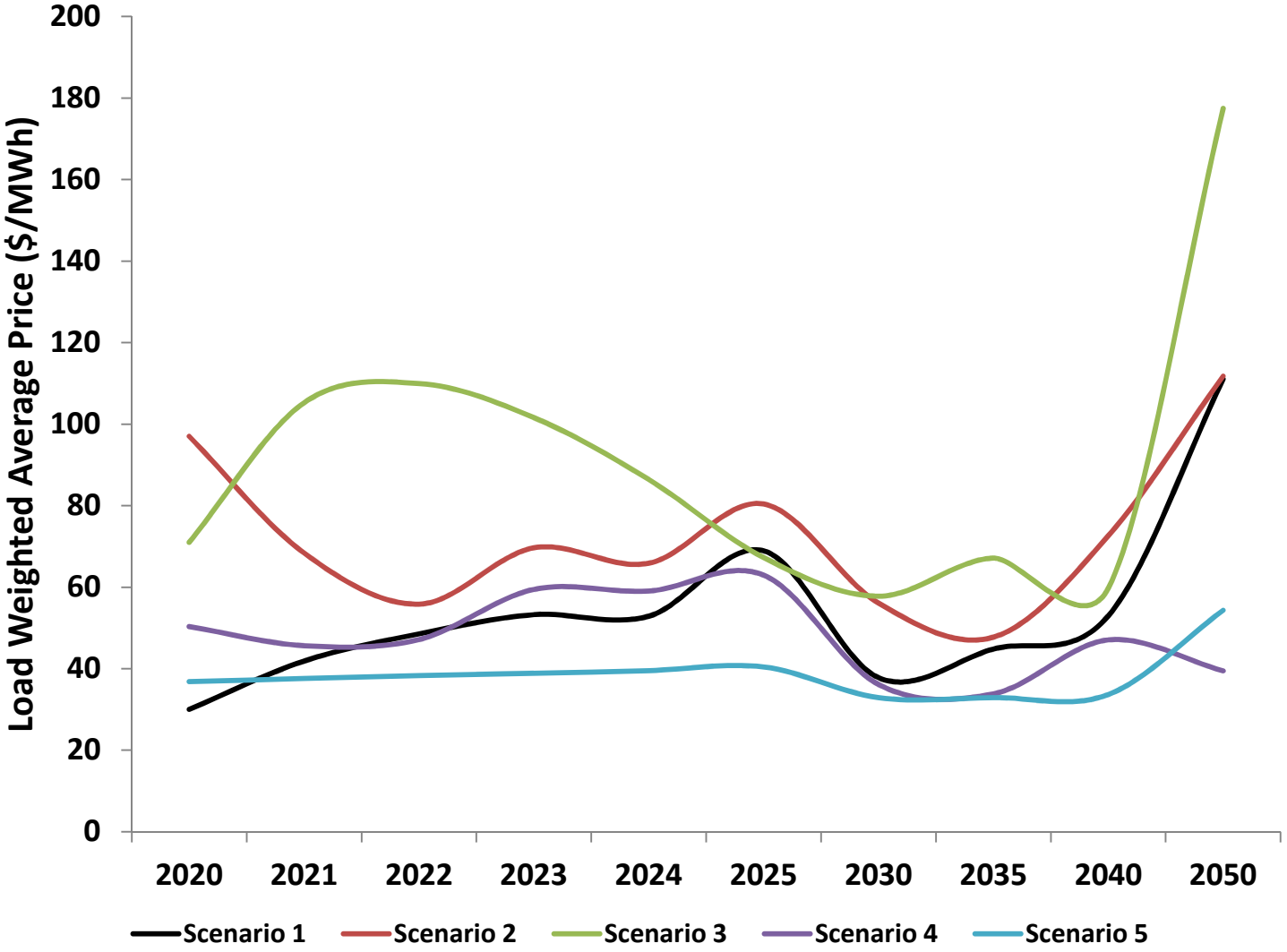
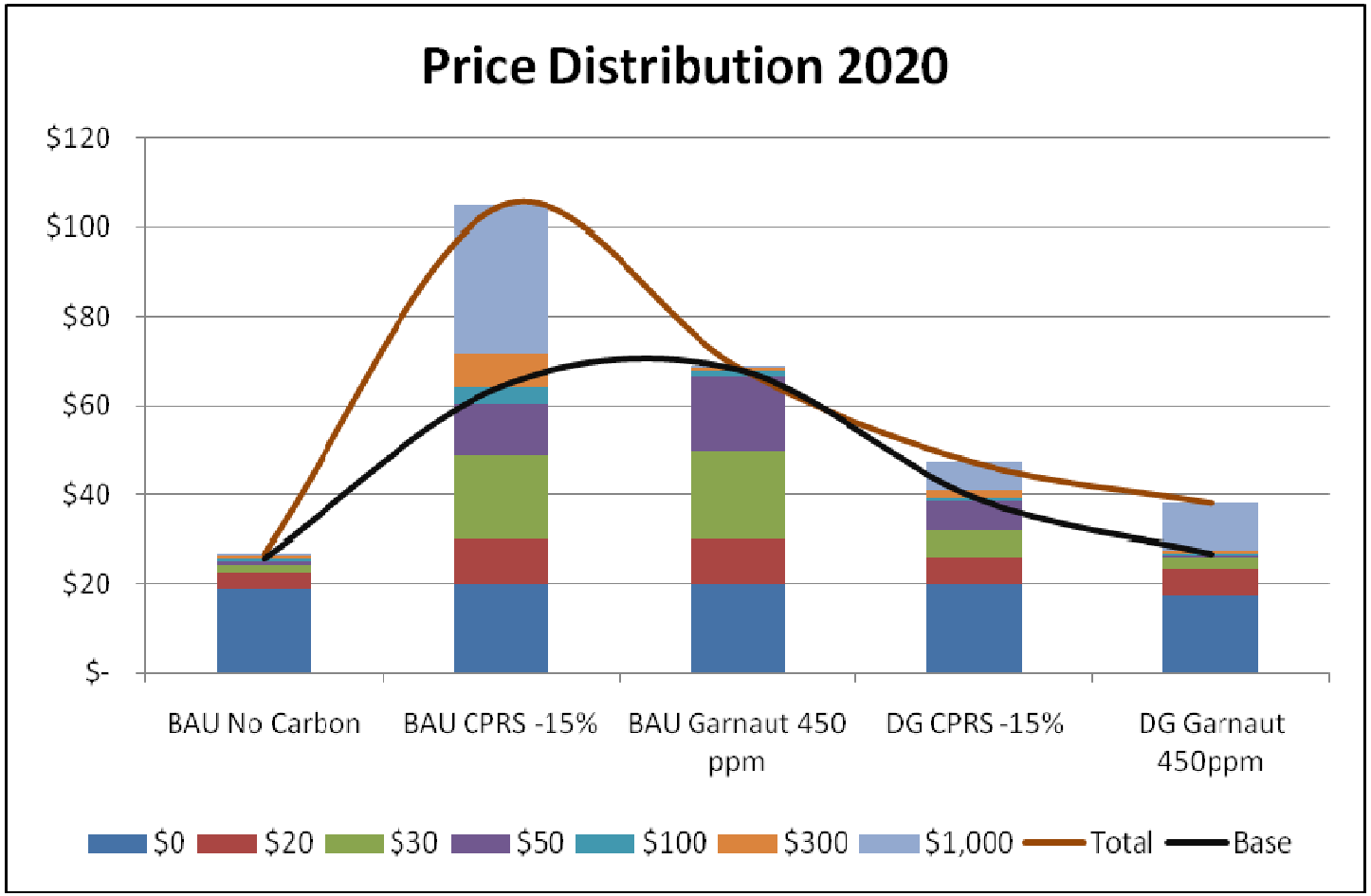
NEM Generation Mix 2020




NEM Generation Mix 2050
Installed GW
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
BAU 2050
CPRS -15%
Garnaut 450ppm
CPRS -15% with DG
Garnaut 450ppm with DG
Black coal pf
Black coal IGCC
Black coal CCS
Brown coal pf
Brown coal IGCC
Brown coal CCS
Gas combined cycle
Gas CCS
Gas peak
Biomass Steam
Wind
Hydro
Solar thermal
Hot fractured rocks
DG

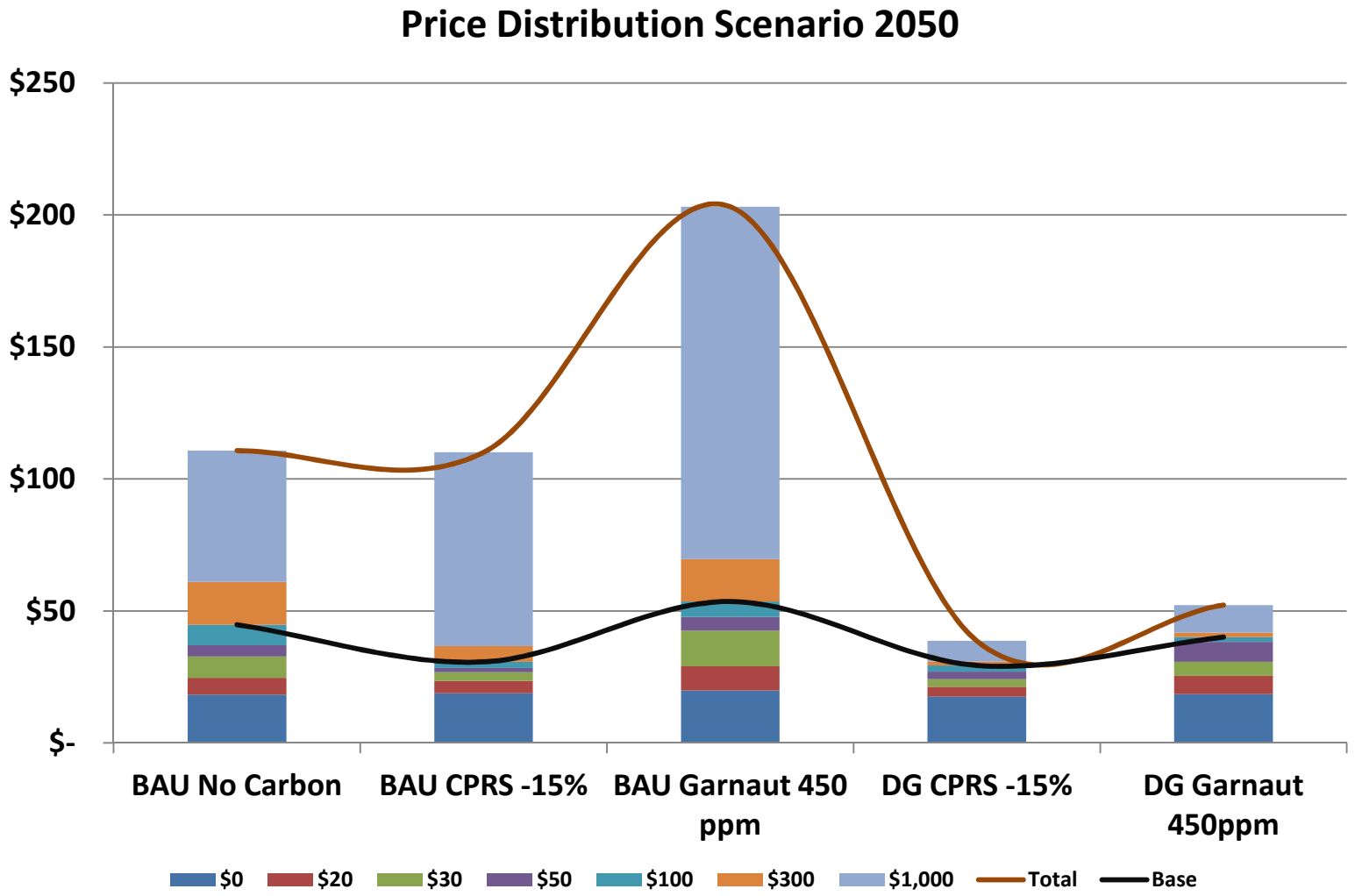
Results


Load Weighted Average Price ($/MWh)
200
180
160
140
120
100
80
60
40
20
0
2020
2021
2022
2023
2024
2025
2030
2035
2040
2050
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5



Average Prices

	NSW	QLD	SA	TAS	VIC
Scenario 1	$28.20	$26.59	$37.13	$15.60	$24.76
Scenario 2	$80.92	$165.54	$70.38	$68.52	$68.54
Scenario 3	$81.61	$71.71	$62.01	$62.01	$49.48
Scenario 4	$39.54	$36.13	$67.65	$67.65	$66.11
Scenario 5	$35.95	$35.06	$39.78	$39.78	$31.51



Average Prices 2050 ($/MWh)

	NSW	QLD	SA	TAS	VIC
Scenario 1	$97.86	$151.15	$101.37	$75.65	$75.66
Scenario 2	$107.72	$117.39	$113.28	$105.29	$105.29
Scenario 3	$268.45	$283.26	$28.67	$28.67	$53.17
Scenario 4	$36.11	$47.93	$37.81	$37.81	$29.60
Scenario 5	$51.96	$49.63	$59.93	$59.93	$53.57

Conclusions

- The advantages of DG in the Australian National Electricity Market are as follows:
  - Lower price volatility and average prices
  - Reduction of investment risk
  - Reduction in CAPEX for transmission infrastructure
  - Placing more generation inside the distribution network will also reduce resistive line loses, thereby reducing the overall installed capacity.