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# Modelling the deployment of DG on electricity markets: an Australian Case Study

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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?

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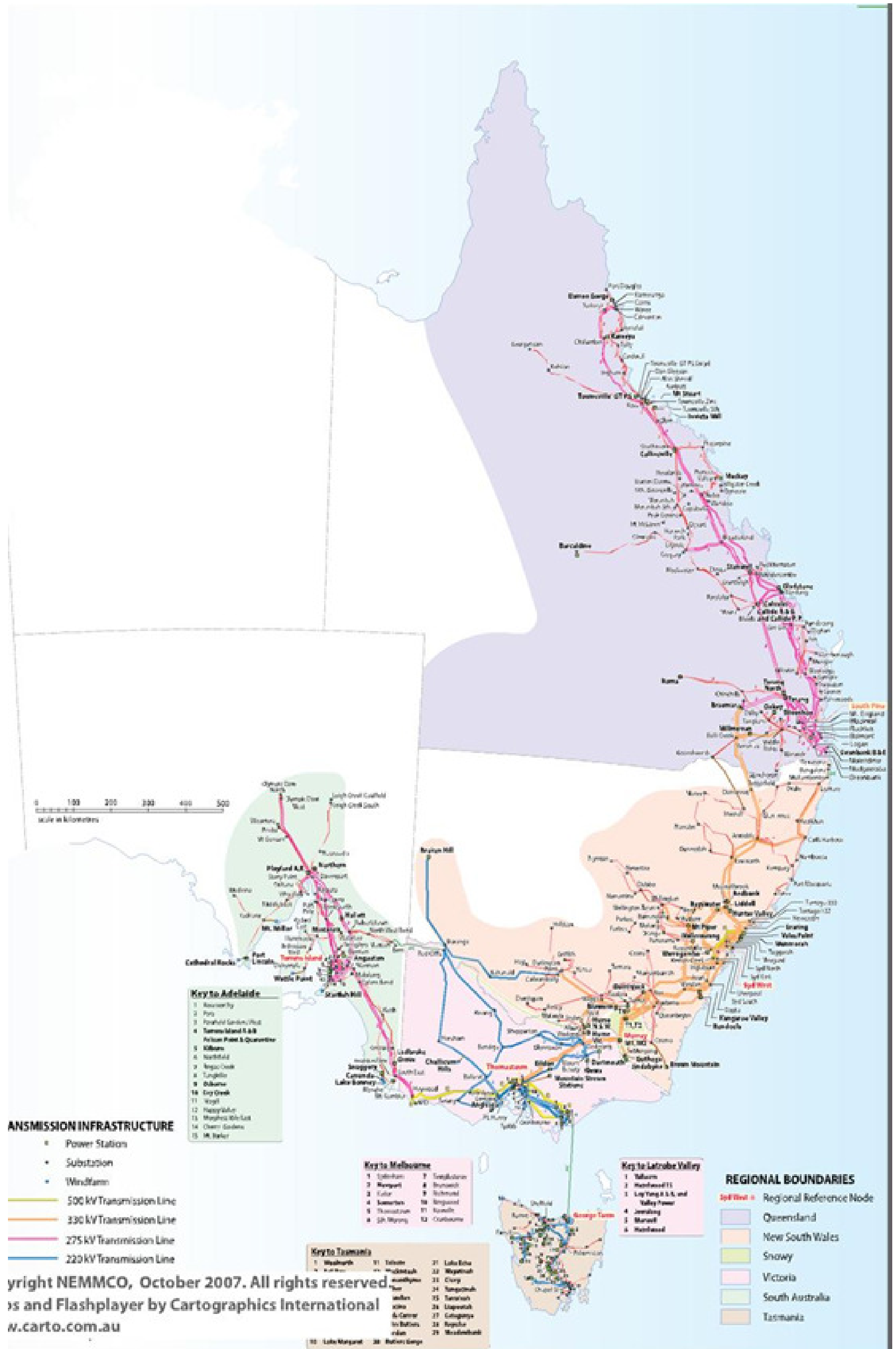


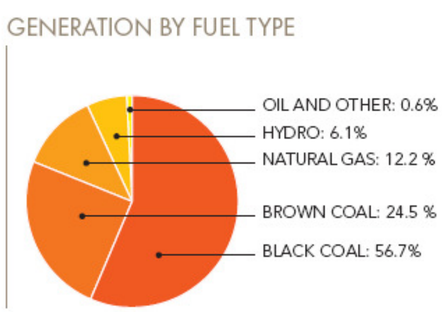

Source: NEMMCO Statement of Opportunities 2007

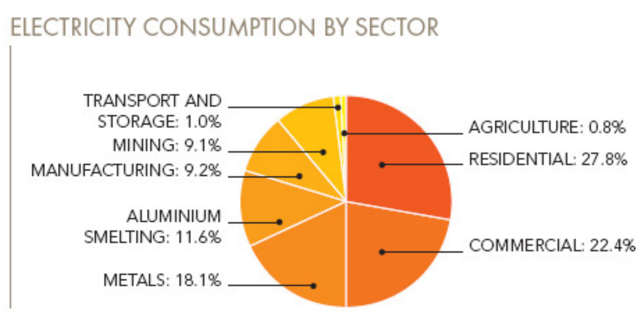
**The 41,000MW supply-side covers all of eastern Australia:**

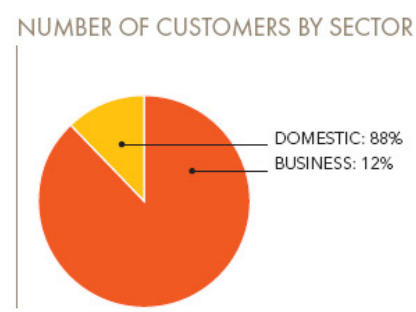
- Queensland 10,400MW
- New South Wales 12,300MW
- Snowy Mountains 3,700MW
- Victoria 8,600MW
- South Australia 3,500MW
- Tasmania 2,500MW

**The demand-side:**

- Aggregate demand (simultaneous) 32,000MW
- Aggregate energy 205,000GWh
- $CO_2$ emissions at approx 180Mt, about 35% of the national total




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

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# Modelling

We consider 3 distinct years in a 40 year planning horizon out to 2050. The following five policy frameworks were modelled as follows:

- **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.
- **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.
- **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.
- **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.
- **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.

## Demand Forecast

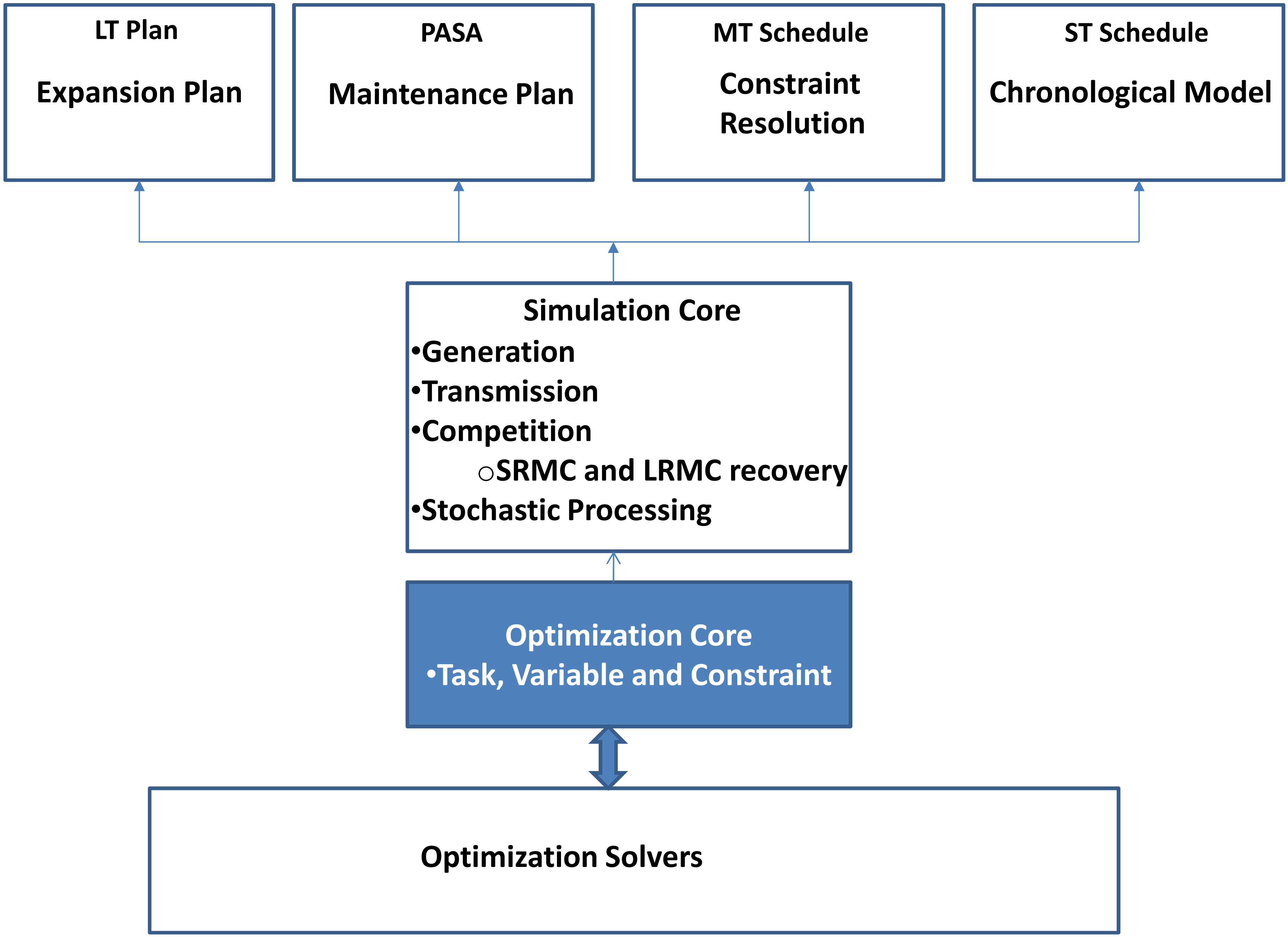
| Demand (TWh) | 2020 | 2030 | 2050 |
|---|---|---|---|
| BAU | 270 | 331 | 481 |
| CPRS -15% | 246 | 241 | 328 |
| Garnaut 450ppm | 230 | 198 | 324 |
| CPRS -15% with DG | 252 | 270 | 344 |
| Garnaut 450ppm with DG | 245 | 256 | 344 |
| **Change from BAU** | **2020** | **2030** | **2050** |
| CPRS -15% | -8.8% | -27.2% | -31.8% |
| Garnaut 450ppm | -15.0% | -40.2% | -32.5% |
| CPRS -15% with DG | -6.7% | -18.6% | -28.4% |
| Garnaut 450ppm with DG | -9.2% | -22.7% | -28.4% |

**Carbon Price Forecasts**

| | CPRS-15% | Garnaut 450ppm (-20%) |
|---|---|---|
| **2020** | 50.02 | 61.06 |
| **2030** | 72.70 | 88.41 |
| **2050** | 157.90 | 199.37 |

# 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.

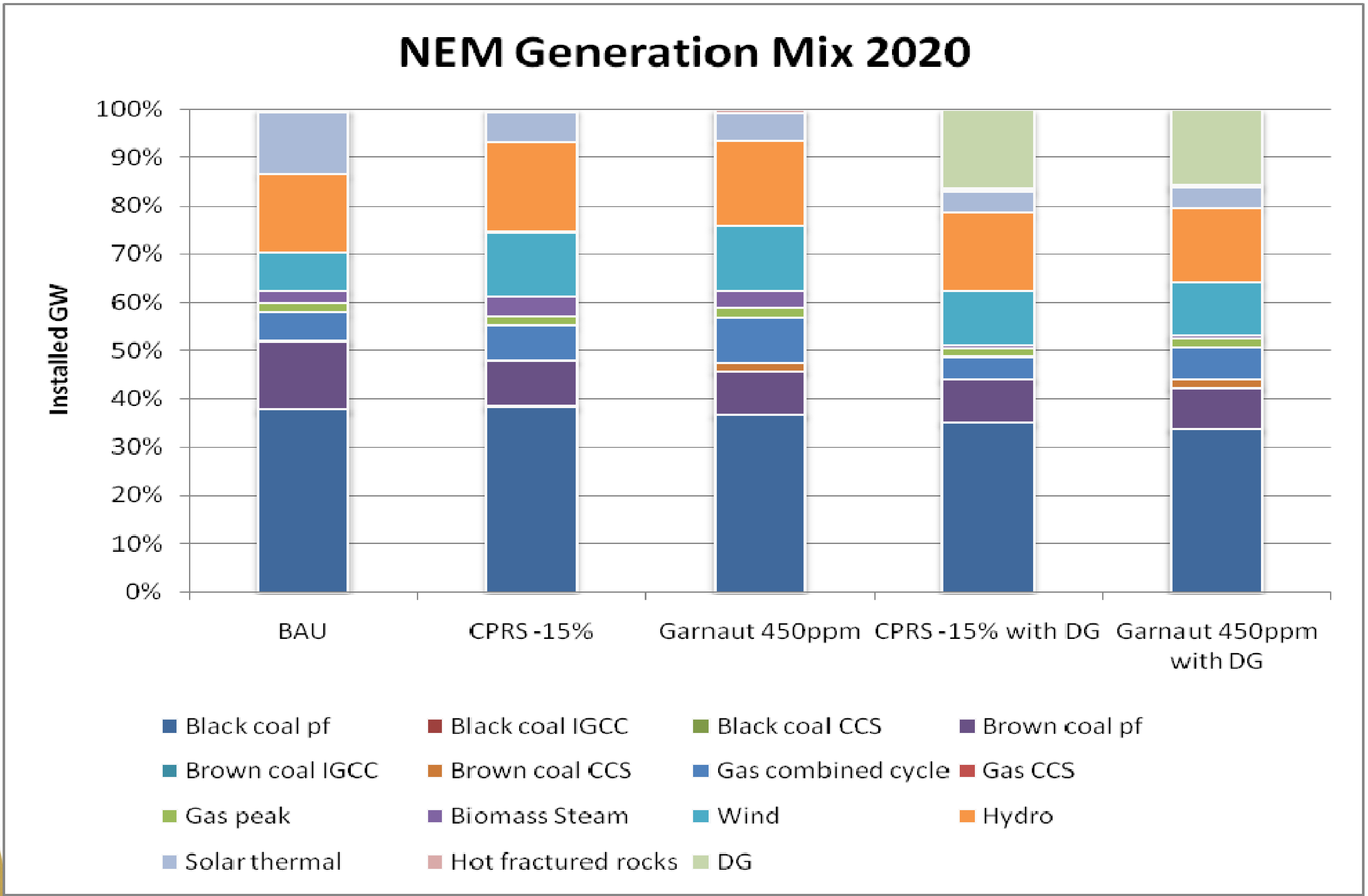

LT Plan
Expansion Plan
PASA
Maintenance Plan
MT Schedule
Constraint Resolution
ST Schedule
Chronological Model
Simulation Core
•Generation
•Transmission
•Competition
○SRMC and LRMC recovery
•Stochastic Processing
Optimization Core
•Task, Variable and Constraint
Optimization Solvers

# Distributed Generation

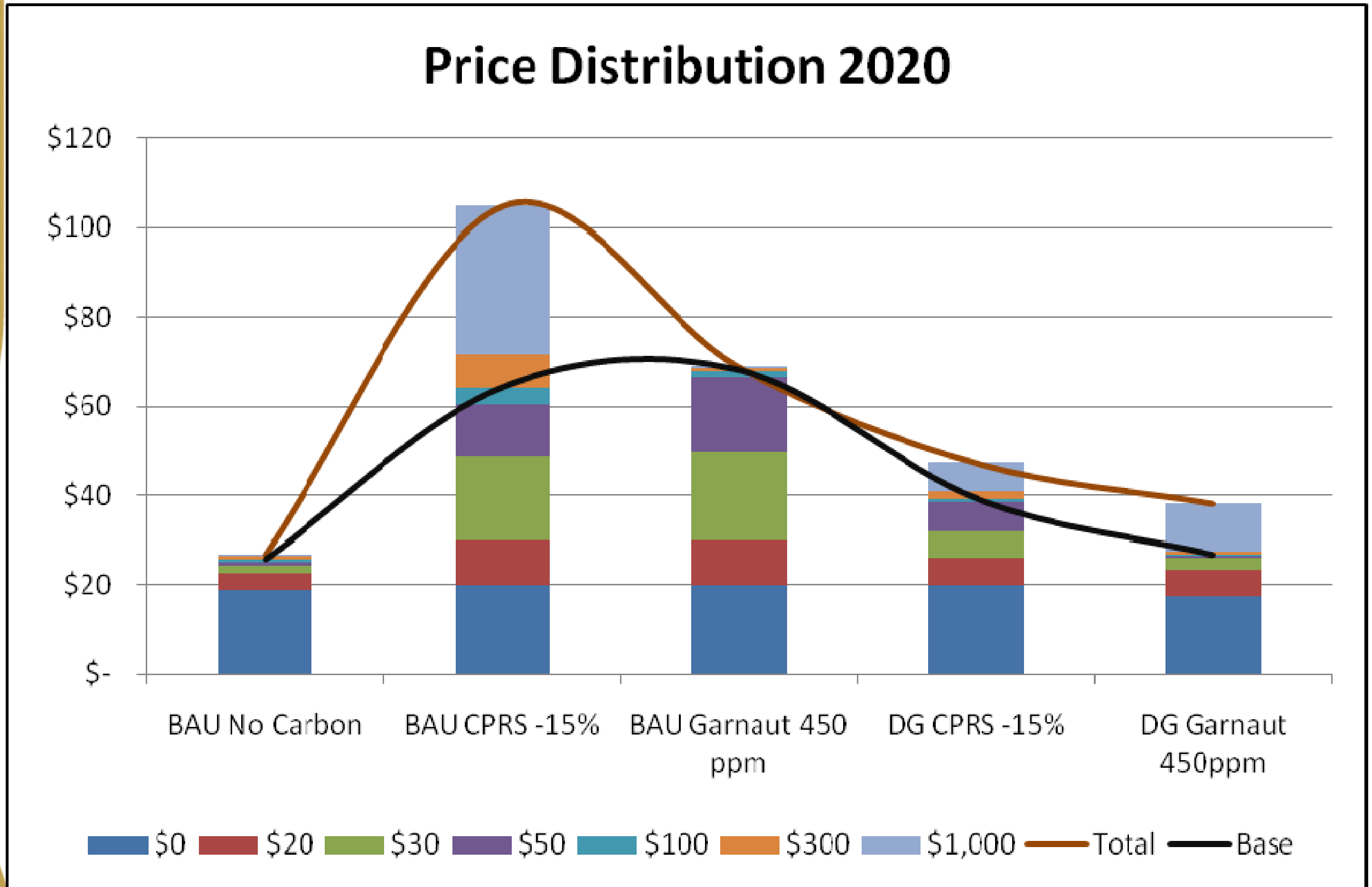
- The roll out of Distributed Generation (DG) could have a significant impact on the NEM.
- Deployment of rapid start/ramp up plant could significantly reduce extreme price spikes (especially at peak time)
- Recent study suggests a reduction in average price and emissions

# 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

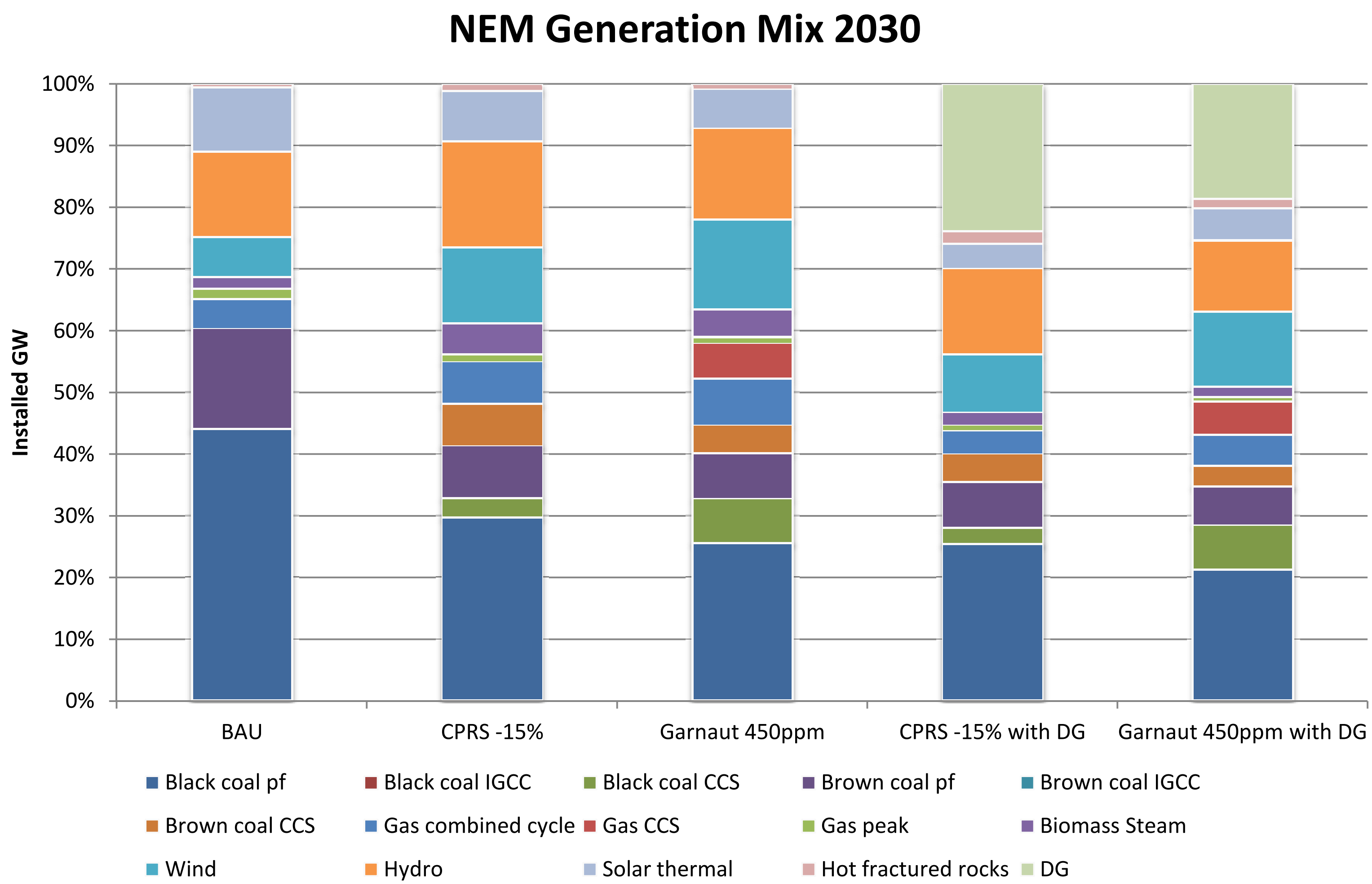



| | GHG Emissions (MT/year) | Emissions Intensity Factor ($tCO_2/MWh$) |
|---|---|---|
| **Scenario 1** | 229.566 | 0.944 |
| **Scenario 2** | 223.731 | 0.878 |
| **Scenario 3** | 201.205 | 0.795 |
| **Scenario 4** | 199.952 | 0.776 |
| **Scenario 5** | 199.196 | 0.791 |

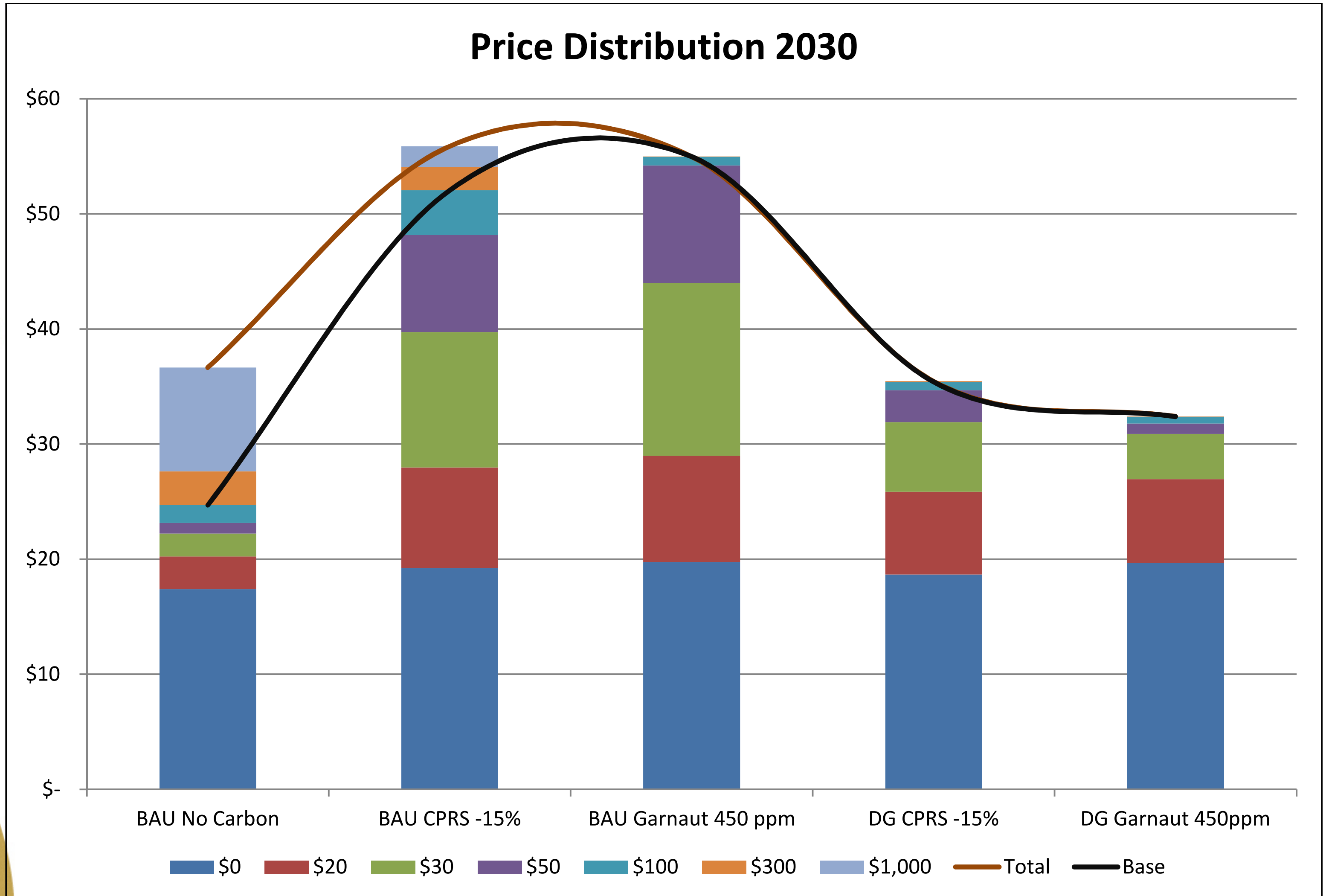



## Average Prices

| | 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 |

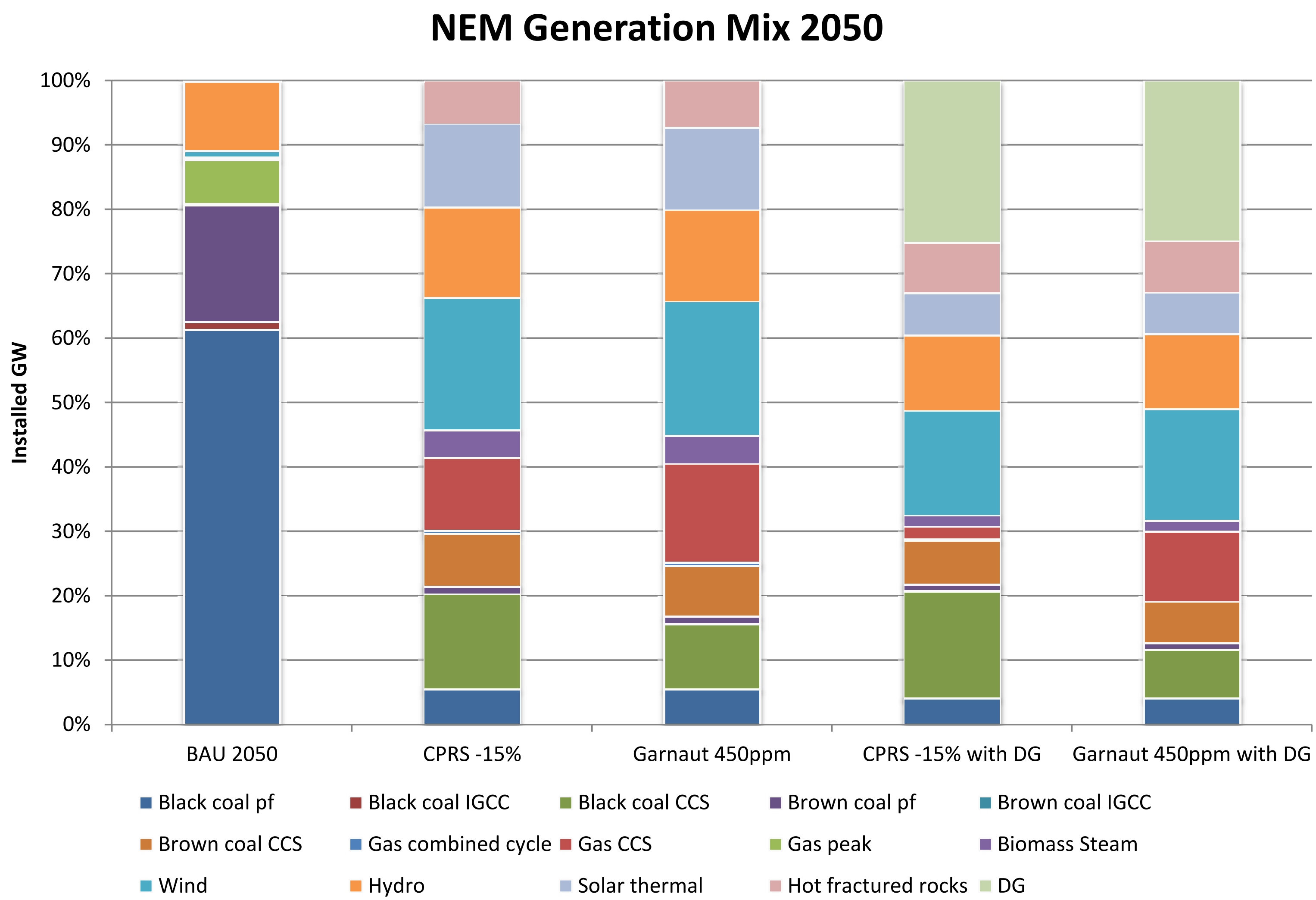



| | GHG Emissions (MT/year) | EIF (T $CO_2e$/MWh) |
|---|---|---|
| **Scenario 1** | 309.6 | 0.93 |
| **Scenario 2** | 96.7 | 0.429 |
| **Scenario 3** | 112.0 | 0.500 |
| **Scenario 4** | 97.4 | 0.39 |
| **Scenario 5** | 110.7 | 0.433 |

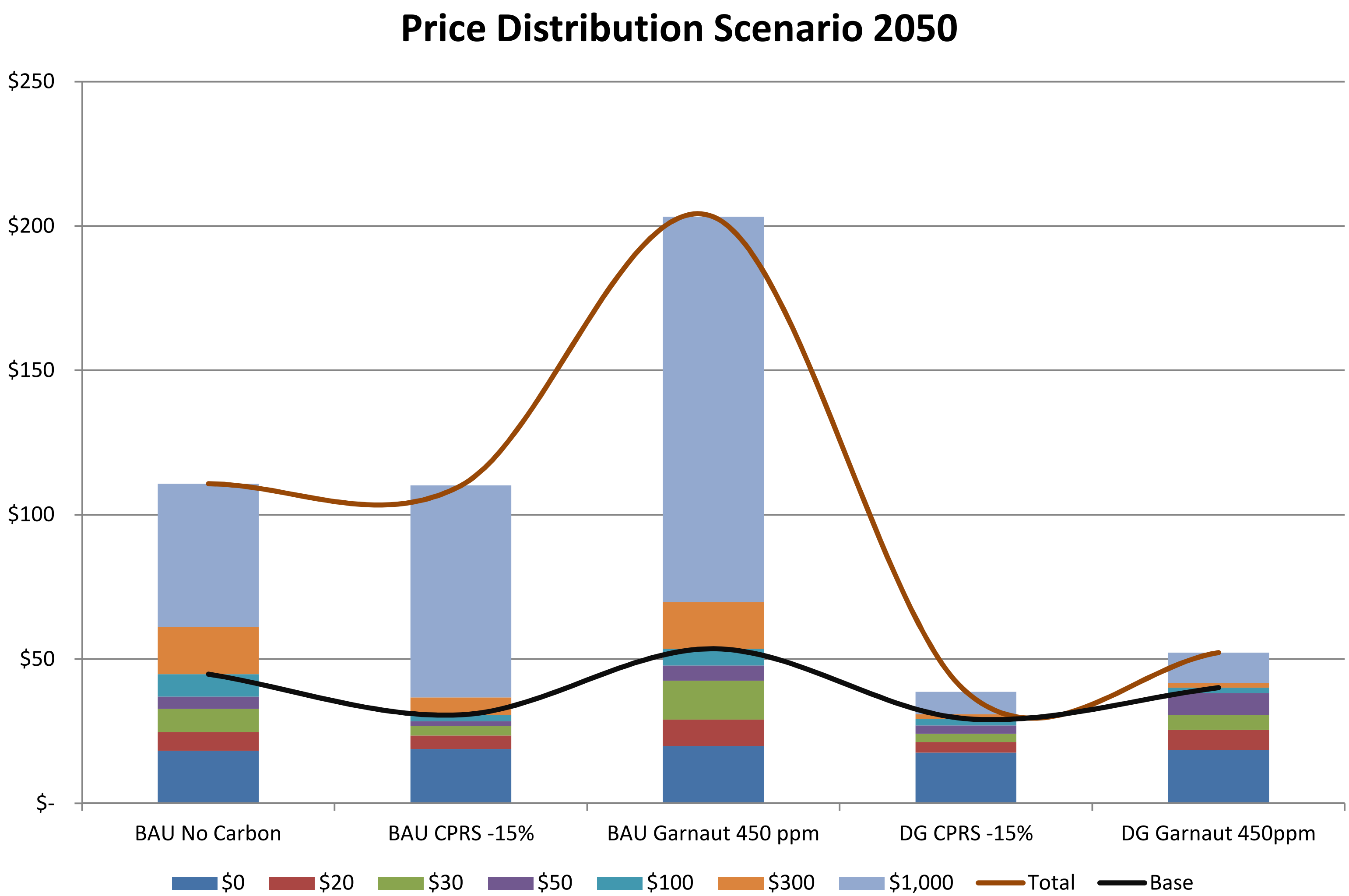



## Average Prices 2030 ($/MWh)

| | NSW | QLD | SA | TAS | VIC |
|---|---|---|---|---|---|
| **Scenario 1** | $27.82 | $53.07 | $38.83 | $18.22 | $24.61 |
| **Scenario 2** | $57.75 | $72.69 | $47.17 | $38.65 | $38.67 |
| **Scenario 3** | $48.39 | $62.25 | $63.02 | $63.02 | $50.95 |
| **Scenario 4** | $39.70 | $34.77 | $34.51 | $34.51 | $31.44 |
| **Scenario 5** | $26.65 | $39.69 | $33.09 | $33.09 | $30.53 |




| | GHG Emissions (MT/year) | EIF (T $CO_2$e/MWh) |
|---|---|---|
| **Scenario 1** | 545 | 0.97 |
| **Scenario 2** | 31 | 0.14 |
| **Scenario 3** | 70 | 0.31 |
| **Scenario 4** | 27 | 0.11 |
| **Scenario 5** | 54 | 0.21 |




**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 emissions intensity of delivered electricity
  - Lower price volatility and average prices
  - Reduction in CAPEX for transmission infrastructure