Project 3: Economic and Investment Models For Future Grids

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Synopsis

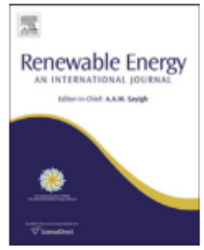
Project Progress:

- Review of economic barriers to entry for utility scale renewables
- Development of technology cost evaluation platform
- Development of economic model of the Eastern Australian Gas Market
- Scenario development for Electricity Market Simulations
- Analysis of availability and suitability of electricity market data
- NEM topology construction in PLEXOS and ANEM market models
- Assessment of remote and embedded renewable electricity generation options

Contents lists available at SciVerse ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene



Australian renewable energy policy: Barriers and challenges

Liam Byrnes [a,b,*], Colin Brown [a], John Foster [b], Liam D. Wagner [b]

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- The Australian government is committed to transition domestic power generation to lower-emissions intensive gas.
- Using PLEXOS we model what a transition to gas fired generation in the year 2035 would deliver.
- Compares a transition to power from gas to that from renewable technologies without total replacement of the existing fleet.
- Results show a transition to gas reduces emissions marginally but wholesale prices are higher than transition to renewables.

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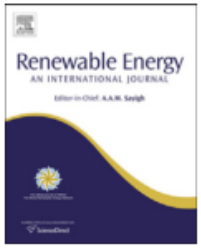

Australian power: Can renewable technologies change the dominant industry view?☆

Lynette Molyneaux*, Craig Froome, Liam Wagner, John Foster

Energy Economics and Management Group, School of Economics, and, Global Change Institute, The University of Queensland, St Lucia, Qld 4067, Australia

- We examine Australia's renewable energy policy, regulatory frameworks and incentives.
- This paper identifies the key barriers faced by the renewables industry.
- We show that the current policy framework favours mature technologies at the expense of emerging options.

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The magnitude of the impact of a shift from coal to gas under a Carbon Price

Liam Wagner*, Lynette Molyneaux, John Foster

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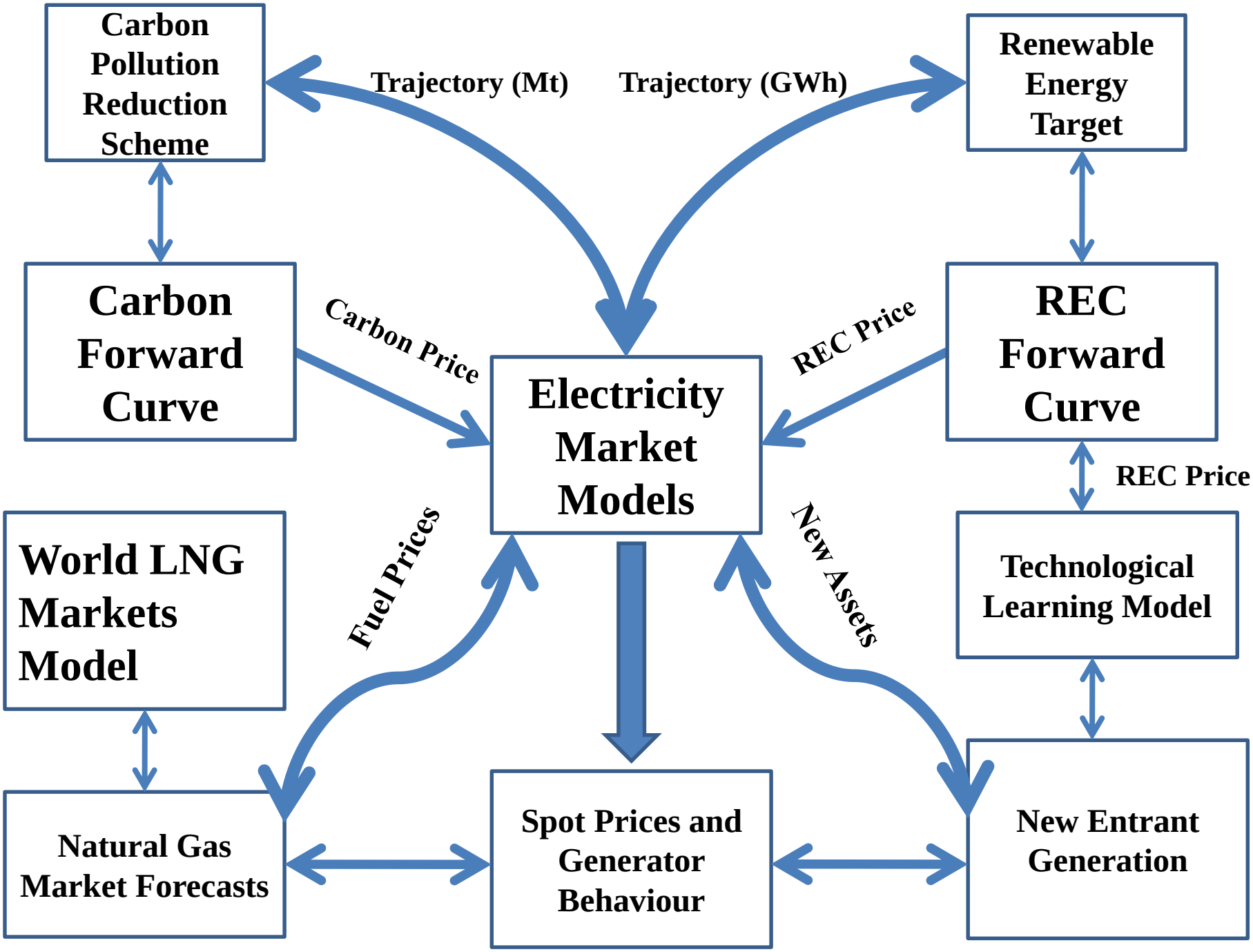
- Marginal cost pass-through rates of increasing cost of carbon are established.
- Market behaviour shifts to infra-marginal rent seeking under increasing carbon and natural gas costs.
- Strategic behaviour of generators is established under these shifting conditions.


Carbon Pollution Reduction Scheme
Trajectory (Mt)
Trajectory (GWh)
Renewable Energy Target
Carbon Forward Curve
Carbon Price
Electricity Market Models
REC Price
REC Forward Curve
REC Price
World LNG Markets Model
Fuel Prices
New Assets
Technological Learning Model
Natural Gas Market Forecasts
Spot Prices and Generator Behaviour
New Entrant Generation

- Plexos for Power Systems
  - Commercially available platform used my NEM generators for trading and market analysis.
  - UQ database constructed to replicate the NEM.
  - UQ has developed a highly detailed model of the NEM for simulating structure change the market.

- 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 optimization and emissions profiles
- Transmission and Interconnector flows.

Key factors which are driving the NEM

- **Gas prices ⇦ (UQ Model)**
- Carbon prices ⇦ (Treasury trajectory)
- Renewable Energy Target ⇦ (UQ modelling)
- Peak Demand ⇦ (AEMO)
- New technology costs ⇦ (Survey)
- Expansion planning
  - Transmission
  - Generation Assets

Gas Prices

- Gas prices will be a significant driving factor in the transformation of Australia's electricity market.
- Uncertainty over prices increases the risks associated with fuel dependency
- Parity pricing of gas with international markets has proved challenging for WA and development of new generation
- To address this uncertainty we have developed an international LNG trade model to forecast price and market behaviour.

Gas Prices

- The UQ international LNG forecasting tool has been developed to provide clarity with respect to the following factors:
  - Long term Mergers and Acquisitions of participants
  - Demand shifts/shocks
  - Supply development
  - Changing market structure from supply side dominance to demand side power.

Gas Model Characteristics

Two Competition types:

- Perfect Competition
- Oligopolistic Competition (Nash-Cournot)

The model is described by the following physical/operational characteristics:

- Pipeline flows
    - Both bi-directional and some uni-directional connections
    - Differential tariffs for each direction
    - Max/Min-flow constraints
- Production
    - Min and Max production constraints
    - Inter-temporal constraints (Maximum production in line with Ultimately Recoverable Reserves)

Model Characteristics: Demand

Demand (3 Sectors)

- Electricity Generation (GPG)
- Export (LNG)
- Mass Market and Light Industry (MM/LI)

- Each agent (by node) has the following exogenous inputs:
  - Reference Prices
  - Demand
  - Elasticity
  - Min/Max Demand Constraints
- International Market Linkage
  - LNG exports linked to the international benchmark price Cif-Japan
  - Cif is netted back to Curtis (free on board Price)

Model Assumptions

Extensive Coverage

- 61 node network
- 13 Basins
- 111 producing areas
- >100 pipeline flows
- 100+ Agents (aggregated by type at each node)

General Assumptions:

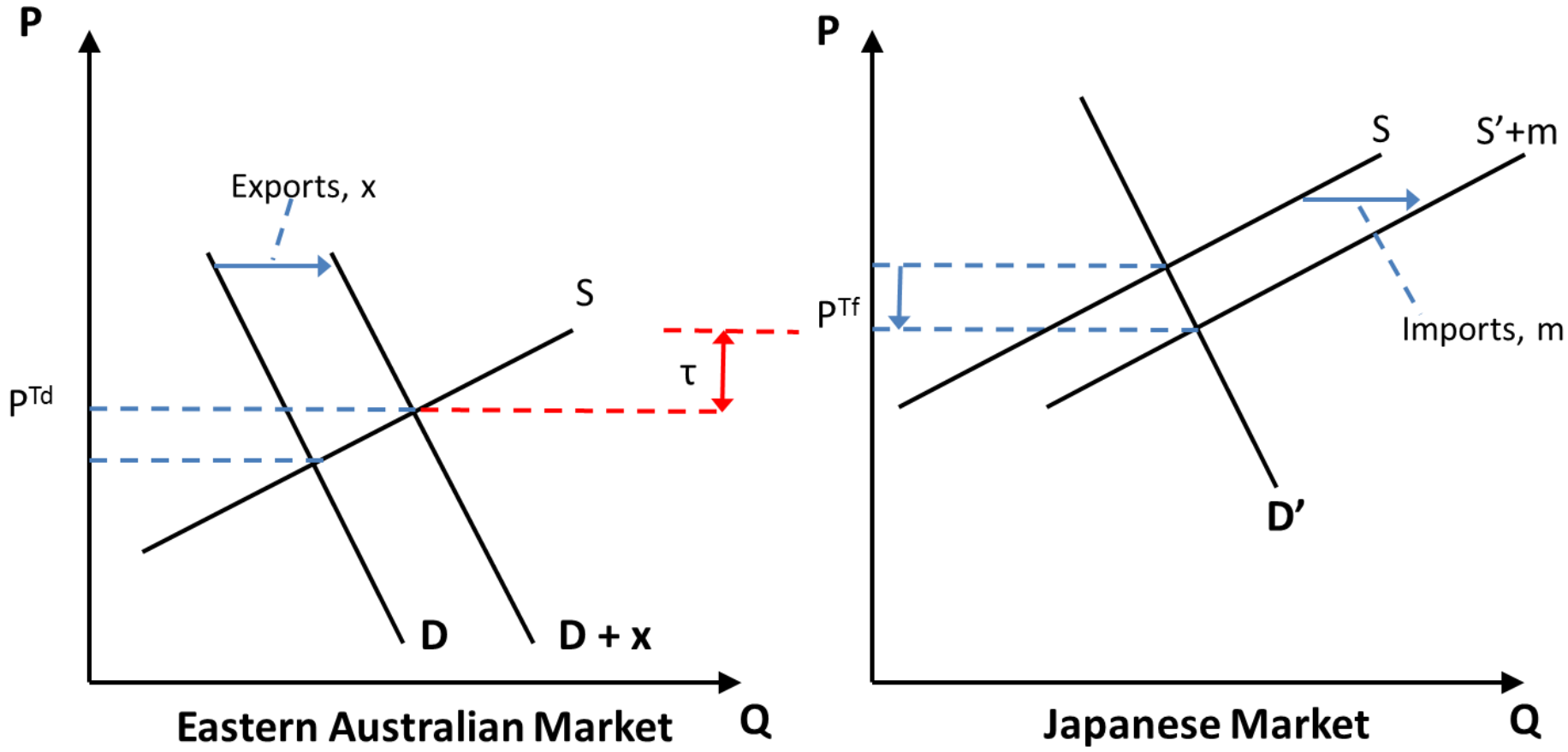
- Pipeline Capacity and Entry (AEMO GSOO)
- Field production (Qld Dept Mines, AEMO GSOO, BREE)
- Reserves (AEMO GSOO
- Electricity Generation (AEMO ESOO 2013)
  - Elasticity -0.7 to -0.3
- Mass Market Light Indusrty (AEMO GSOO, CORE Energy)
  - Elasticity -0.3
- LNG Demand (Core Energy, BREE)

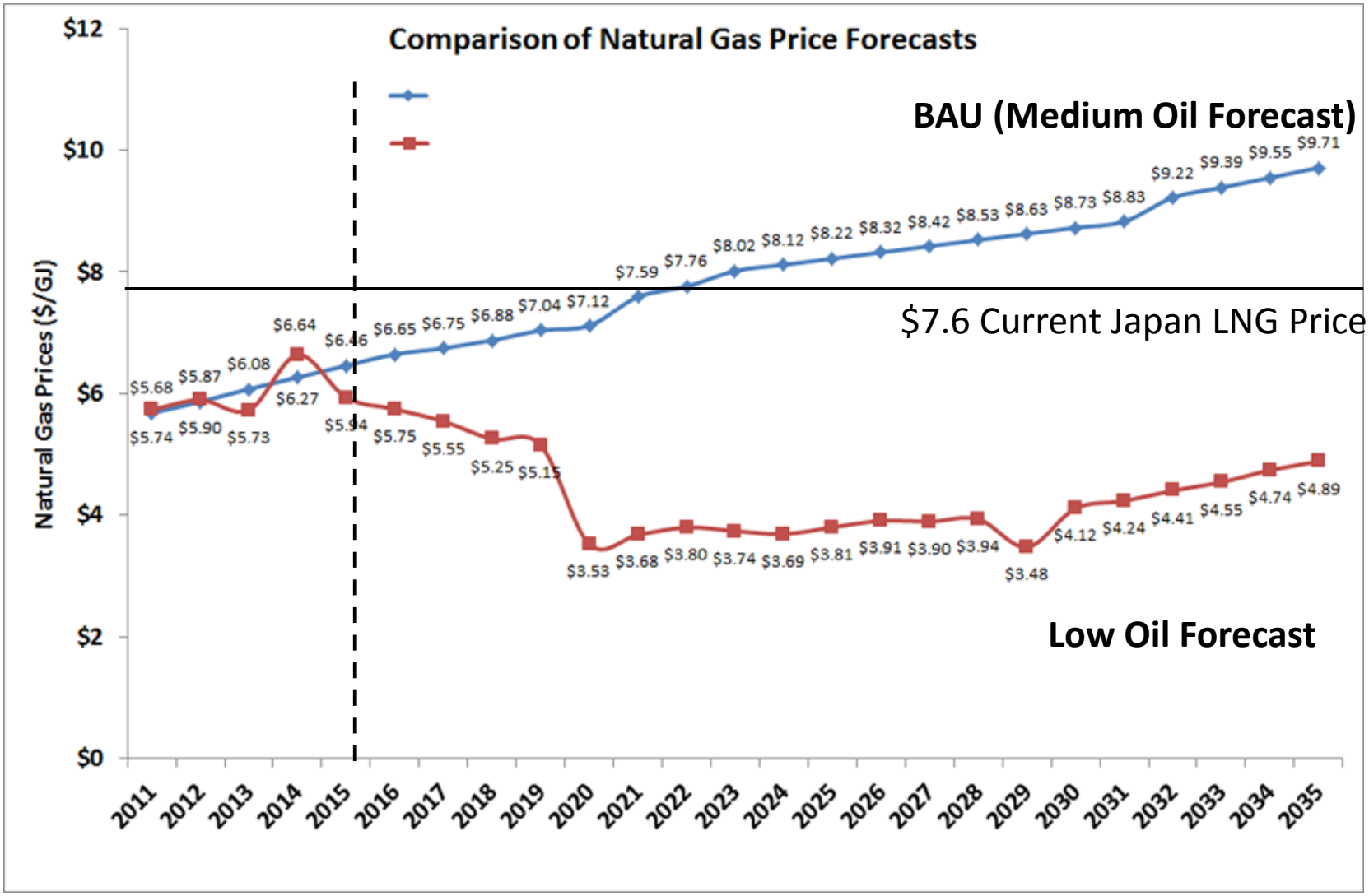
- The supply/demand balance in the near future will contribute to significant shifts in global prices.
- Access to extensive supply increases will transform the trade in energy globally.
- Increasing supply and the potential lowering of prices will result in draw backs in supply.
- M&A activity will increase to counter cheap assets.
- However this will be unlikely to sustain high prices.

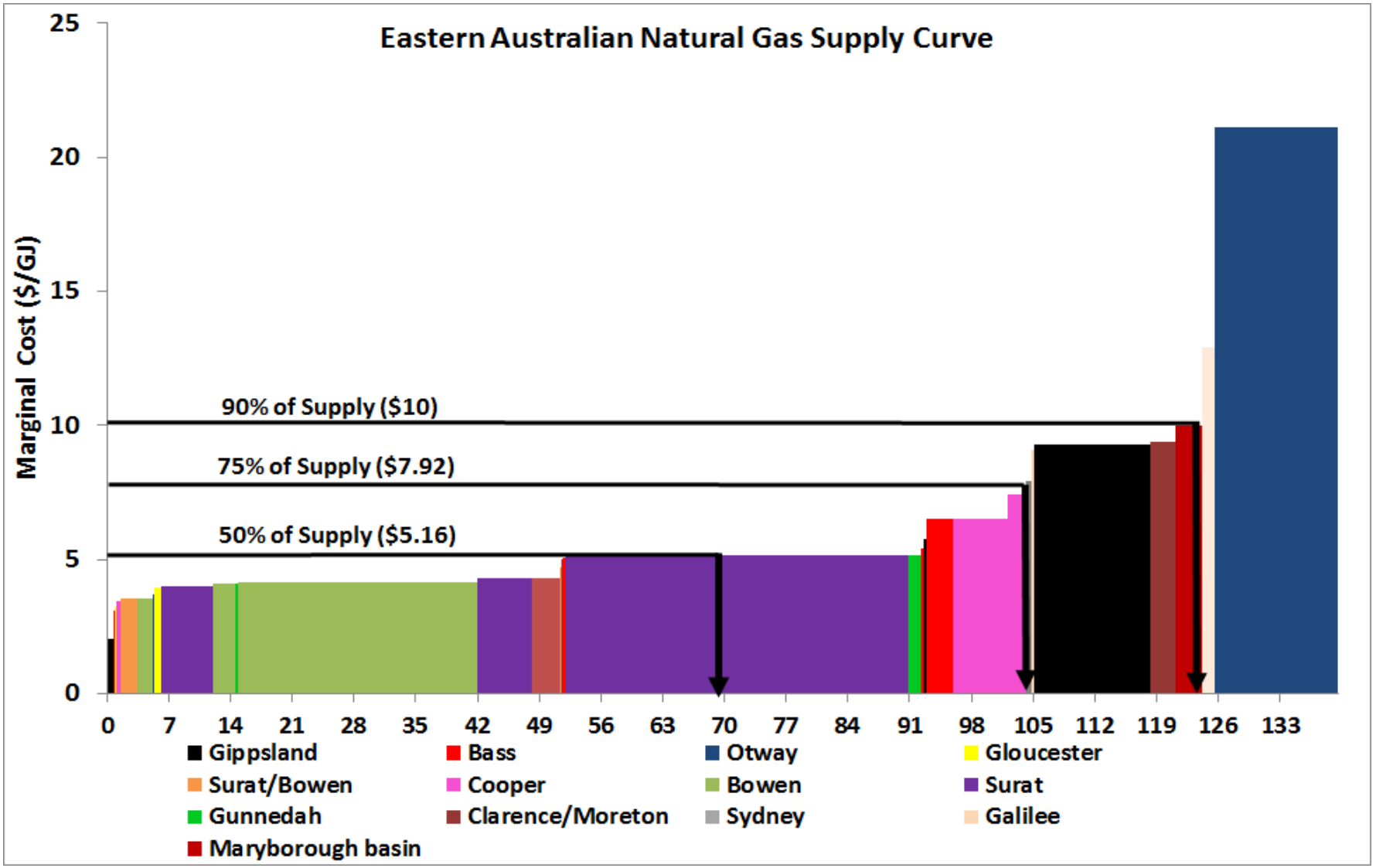
- Any structural changes which are precipitated by large market participants are unlikely to alter the downward price trajectory of the next 20-30 years.
- A relatively disaggregated market will provide demand side participants the opportunity to move away from oil index linked contracts.
- Australian prices (producer opportunity cost/price i.e. FOB-netback) to fall significantly by 2020.

Japanese Benchmark

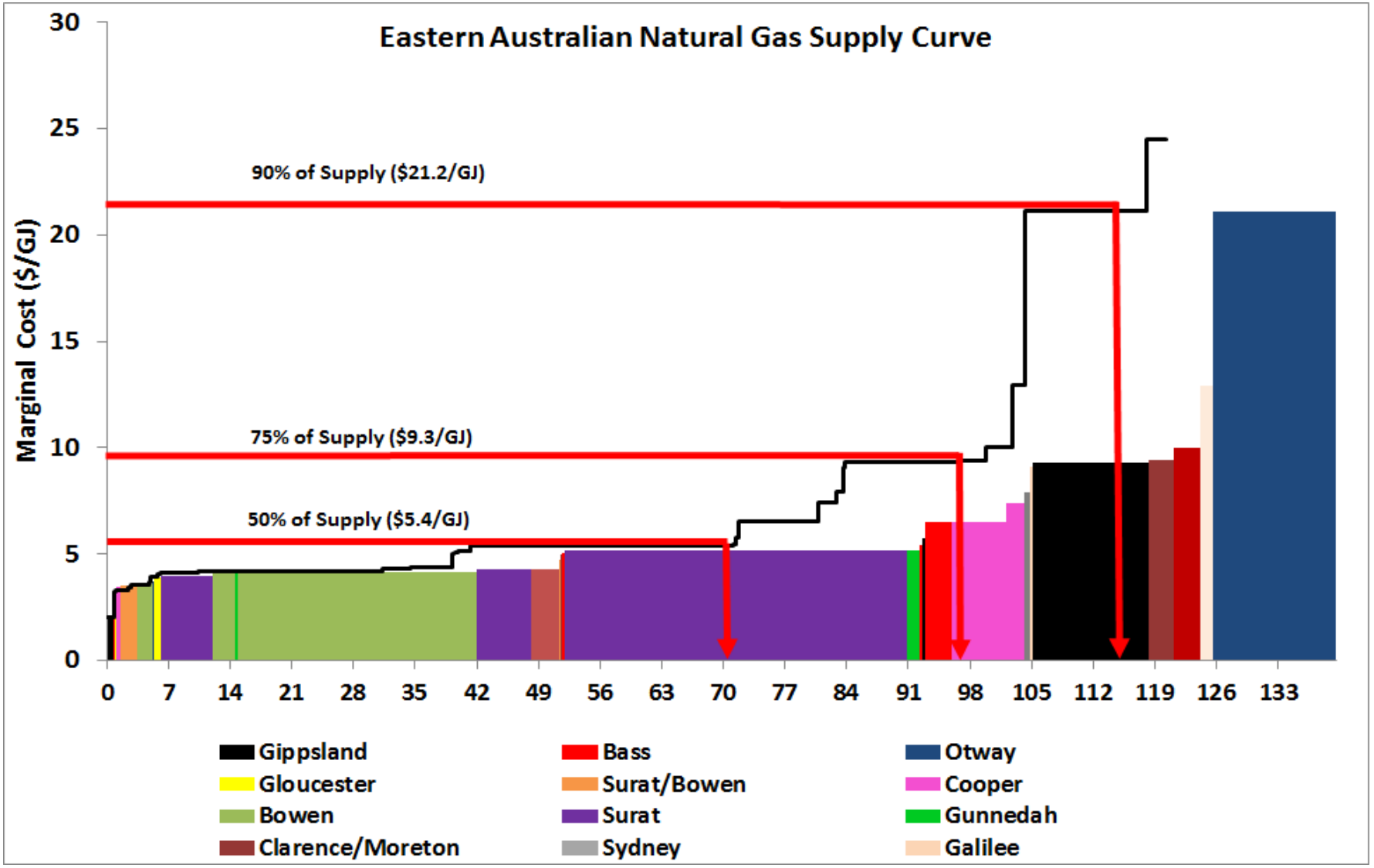
- Trade between two markets, price in each adjusts.
- The adjustment depends on the elasticity of both supply and demand.




Comparison of Natural Gas Price Forecasts
BAU (Medium Oil Forecast)
$7.6 Current Japan LNG Price
Low Oil Forecast
Natural Gas Prices ($/GJ)
$12
$10
$8
$6
$4
$2
$0
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035
$5.68 $5.87 $6.08 $6.27 $6.46 $6.65 $6.75 $6.88 $7.04 $7.12 $7.59 $7.76 $8.02 $8.12 $8.22 $8.32 $8.42 $8.53 $8.63 $8.73 $8.83 $9.22 $9.39 $9.55 $9.71
$5.74 $5.90 $5.73 $6.64 $5.94 $5.75 $5.55 $5.25 $5.15 $3.53 $3.68 $3.80 $3.74 $3.69 $3.81 $3.91 $3.90 $3.94 $3.48 $4.12 $4.24 $4.41 $4.55 $4.74 $4.89



Arrow Delayed



Electricity Market Modelling

- We have established 3 main Scenarios for testing:
  - Scenario 1a: AEMO ESOO
  - Scenario 1b: Counter-factual RET needs to remain
  - Scenario 1c: UQ Gas forecast perturbation

Scenario 1a: AEMO

- Main Assumptions
  - AEMO Fuel Prices
  - RET ends in 2030
  - CCS unavailable
  - No major transmission upgrades
  - Demand Side Participation v. Low
  - Demand Growth mid
  - AEMO Retirement Schedule

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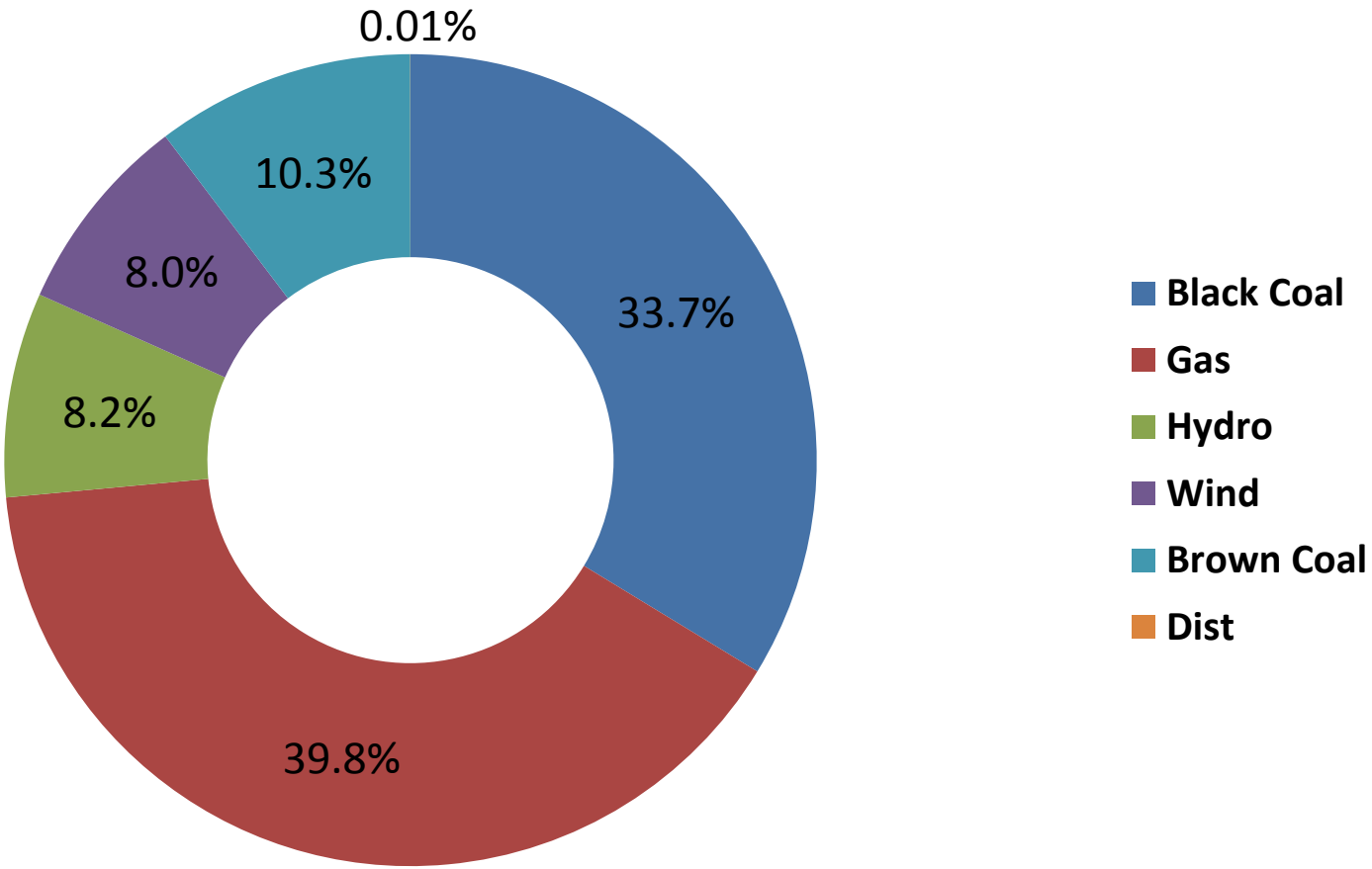
Generation Profile



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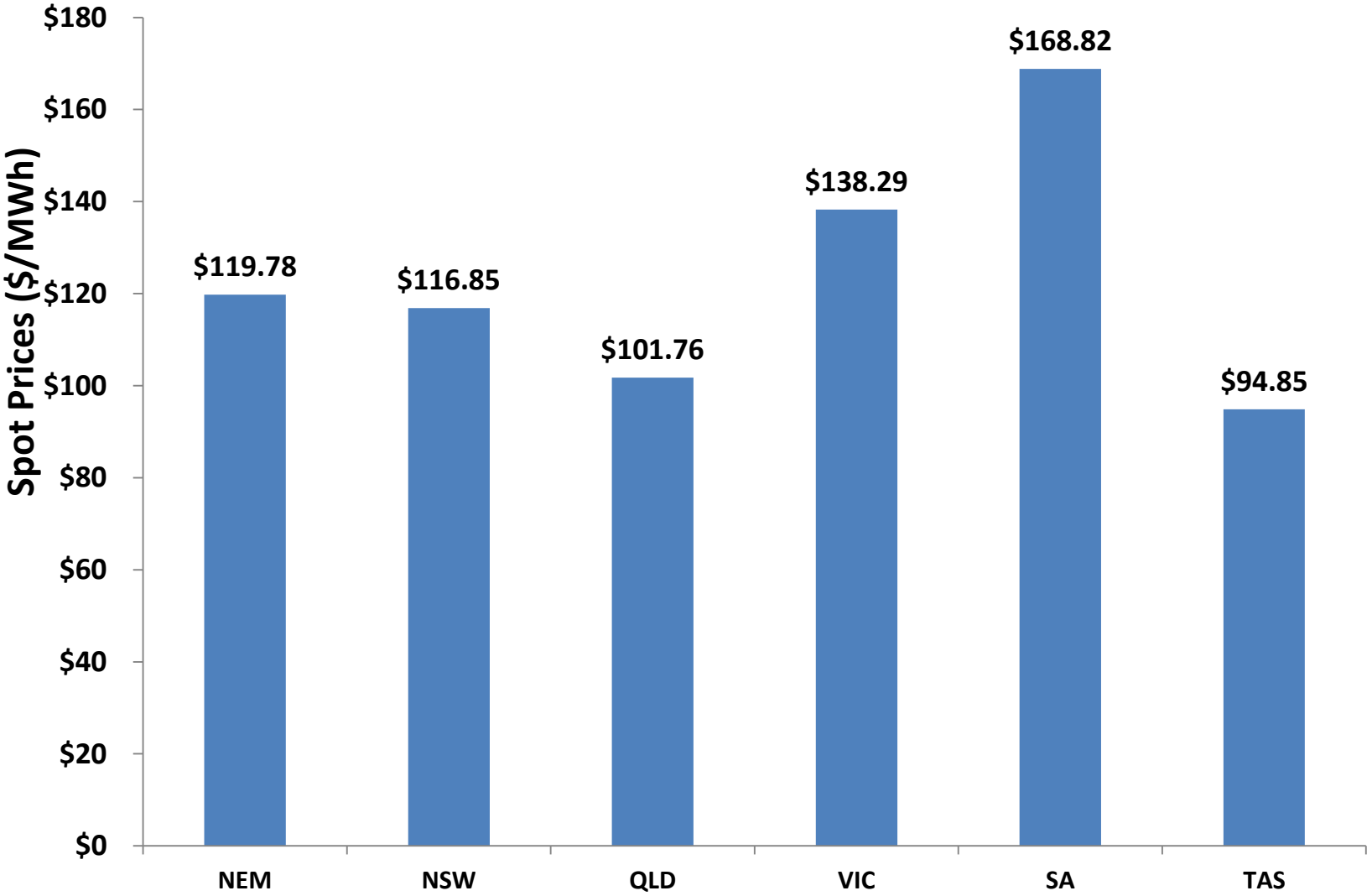
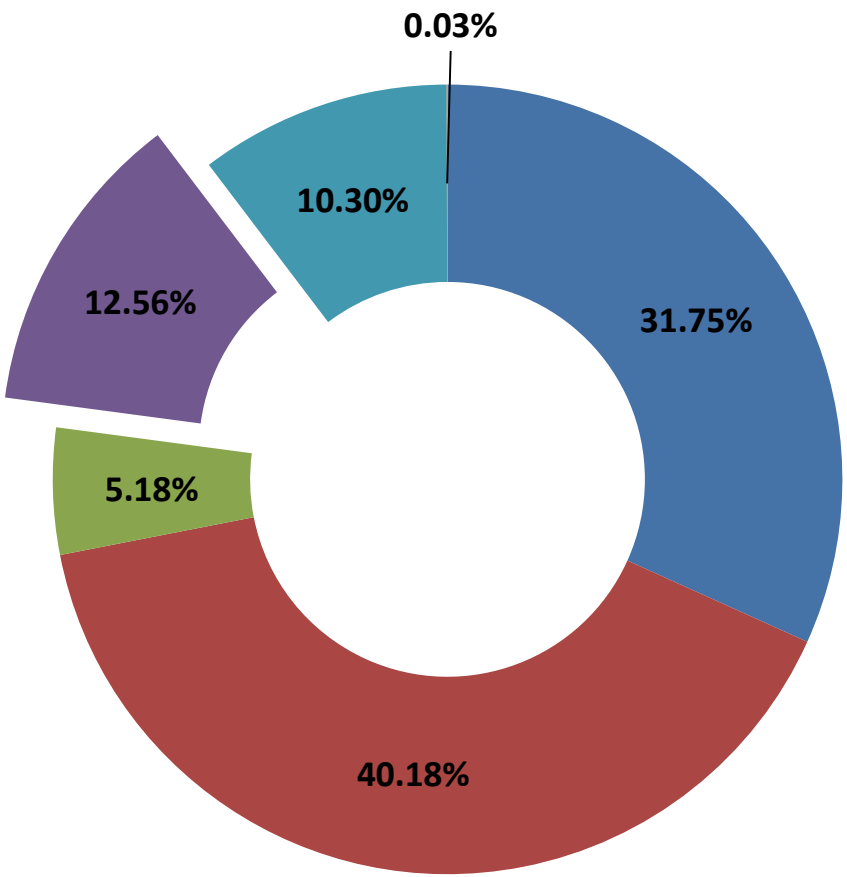
Spot Price Behaviour



- Summary:
  - Emissions Intensity 0.516 t-CO_2/MWh
  - Prices relatively volatile
  - GAS deployment accounts for ~40% of Generation
  - Overall investment in generation $116Bn
  - Carbon Price of $67.28 (Carbon -5%)
  - Reliance on combustive technology

- Scenario 1b: Key points of difference
  - RET continues. (REC price $38/MWh)
  - Carbon and other inputs and other technical data assumptions continued from Scenario 1a.
  - Expectation of high renewables!
  - Deployment rates are calculated on lowest cost to the market and premium available to Genco.

Generation Profile



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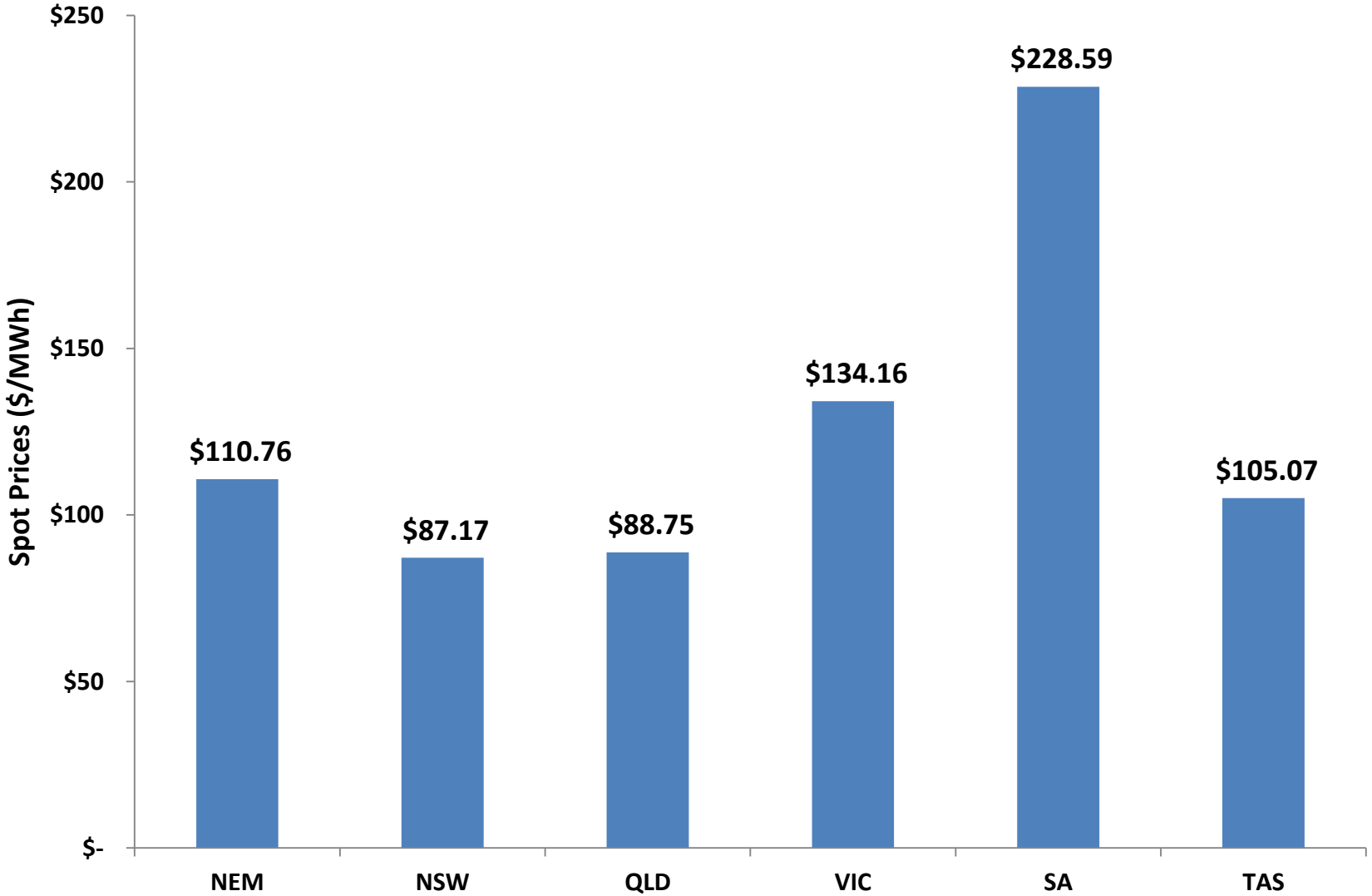
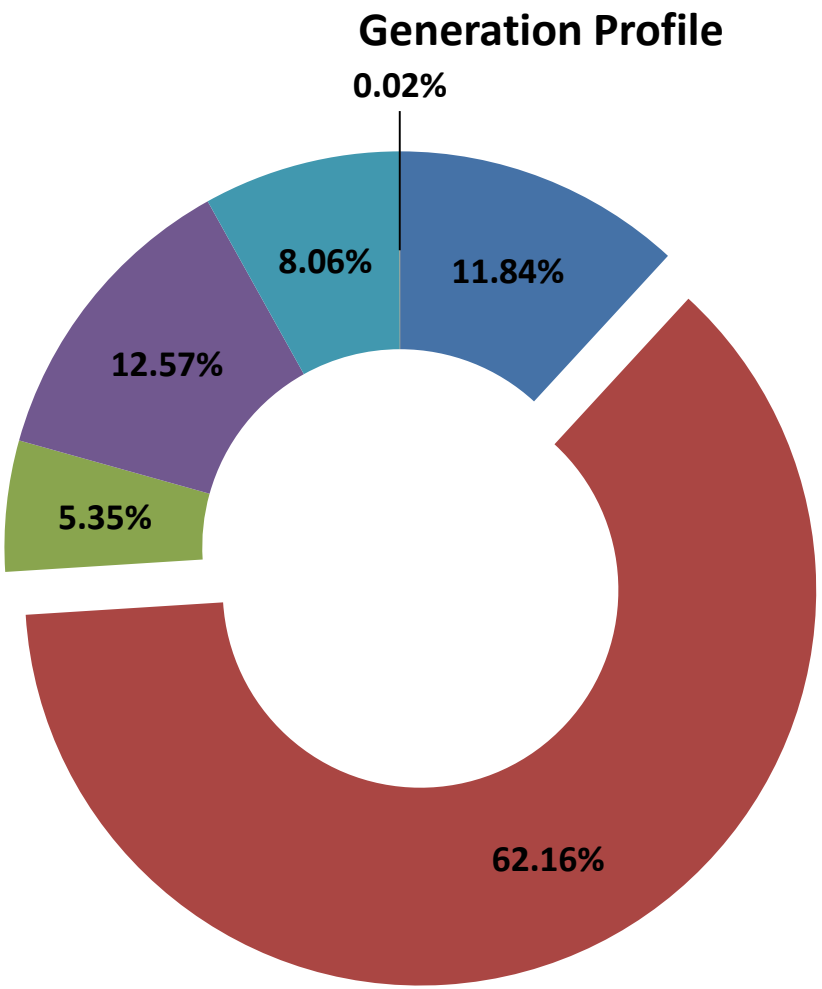
Spot Price Behaviour

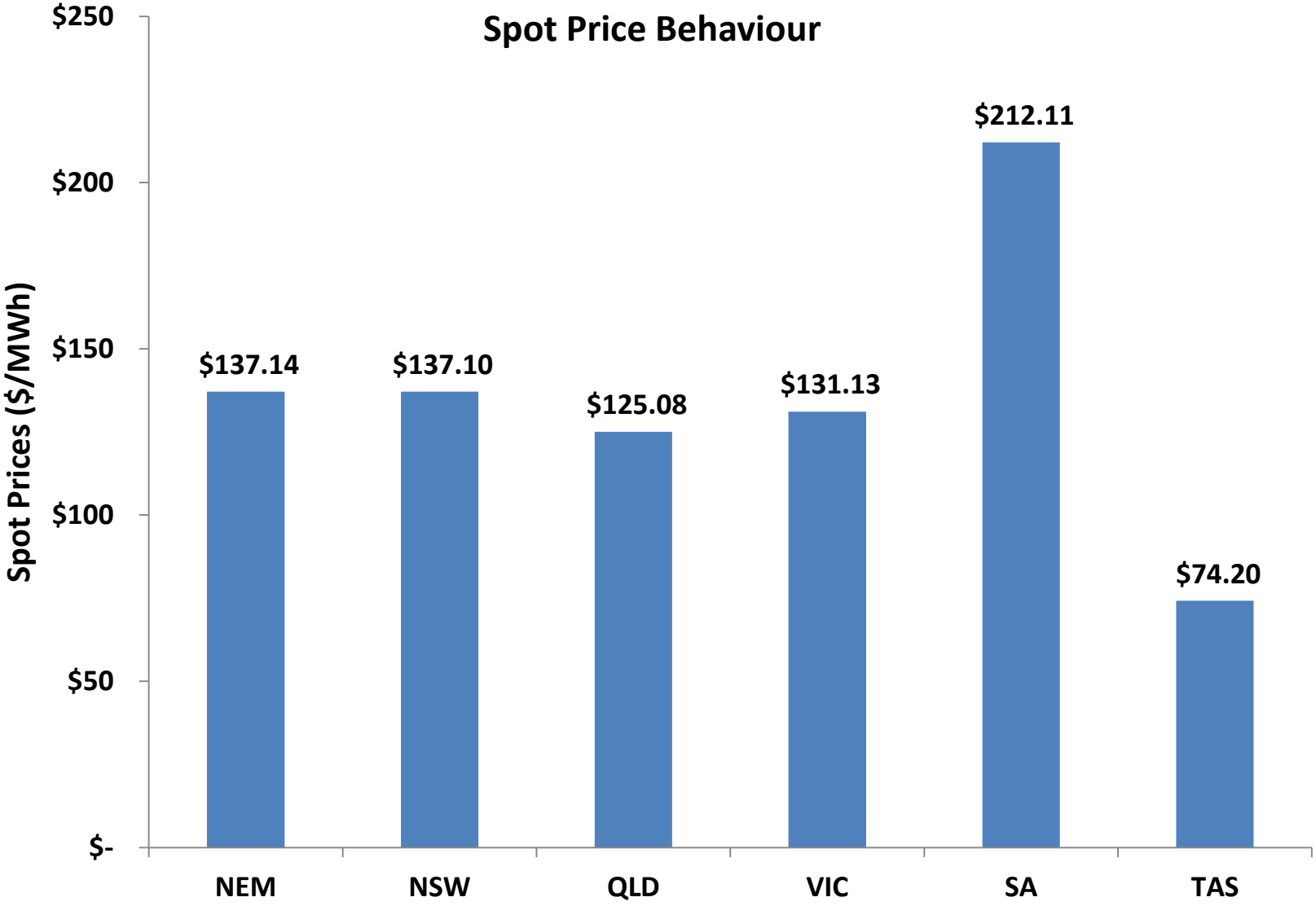


- Summary:
  - 4% increase in wind deployment
  - NEW average price falls
  - Higher deployment of must run/dispatch wind drives price lower
  - Higher price volatility in SA
  - Emissions increase by 4 MT-CO_2
  - SA clearly islanded off due to transmission under-investment. (Transmission led scenario would engage SA differently)

- Scenario 1c:
  - All assumptions from Scen 1a continued with the exception of gas prices.
  - Gas price trajectory significantly lower that AEMO and BREE
  - Expectation of gas investment over wind.
  - RET ceases and renewable investment to lag below 20% of total dispatch


Generation Profile
0.02%
11.84%
8.06%
12.57%
5.35%
62.16%
Black Coal
Gas
Hydro
Wind
Brown Coal
Dist

Spot Price Behaviour



- Summary:
  - 20% increase in gas deployment
  - NEW average price increases to recover LRMC
  - Lower deployment of must run/dispatch wind drives price lower
  - Emissions decrease by 25 MT-CO_2
  - SA is still clearly islanded off due to transmission under-investment.

- Summary:
  - Emissions continue to fall compared to gas driven by 36MT
  - Spot prices relatively low given carbon forward price and gas forecast.
  - Generation investment similar by comparison given load growth.