BIS OXFORD ECONOMICS

AEMO COMMODITIES SCENARIO FORECASTS 2022-23:

REPORT

PREPARED FOR THE AUSTRALIAN ENERGY MARKET OPERATOR

FINAL

9TH SEPTEMBER 2022

09 September 2022

This report is produced for **the Australian Energy Market Operator** as input into their suite of energy forecasting reports. This report is not to be relied upon for any other purposes.

The modelling and results presented here are based on information provided by third parties, upon which BIS Oxford Economics has relied in producing its report and forecasts in good faith. Any subsequent revision or update of those data will affect the assessments and projections shown.

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EXECUTIVE SUMMARY

This report presents the commodity price outlook for the four alternative scenarios outlined in the Australian Energy Market Operator's (AEMO) Input Assumptions and Scenarios Report (IASR) – *Step Change* case, *Progressive Change* case, *Exploring Alternatives case* and the *Hydrogen Export* case.

The forecasts presented are for the following commodities:

1. Brent Crude Oil (AUD/bl)
2. LNG Netback Price (Wallumbilla) (AUD/GJ)
3. Newcastle Thermal Coal Price (AUD/tonne)

Step Change Scenario

The *Step Change* scenario forms AEMO's most likely scenario pathway. It is characterised by moderate macroeconomic growth drivers. Additionally, in the long-run there are coordinated global policy efforts to mitigate carbon emissions. This places the world on a climate warming pathway of 1.8ºC by 2100 (RCP 2.6).

The near-term outlook for these commodities is largely dictated by current market developments. Global policy commitments to decarbonisation becomes a stronger driver in the long-term as it determines the pace of structural shift in demand away from emissions intensive fossil fuels.

Near Term Outlook

Energy commodity prices have experienced a sharp appreciation in recent months. Key themes affecting these markets are the Russia-Ukraine conflict, supply chain pressures, government policy, and further COVID-19 disruptions. We expect these factors to continue to influence the near-term outlook.

Prices are generally expected to peak across all commodities by the end of this quarter (Sep-22), before starting to fall back as supply side pressures ease. In particular, we assume that a long military conflict is avoided in Ukraine and that supply chain bottlenecks unwind through the rest of this year. On the demand side, we expect some of the strength seen in recent months to subside in response to monetary policy tightening and ongoing inflation.

Nevertheless, upside risks to the outlook remain, which are considered in the alternate scenario outlooks.

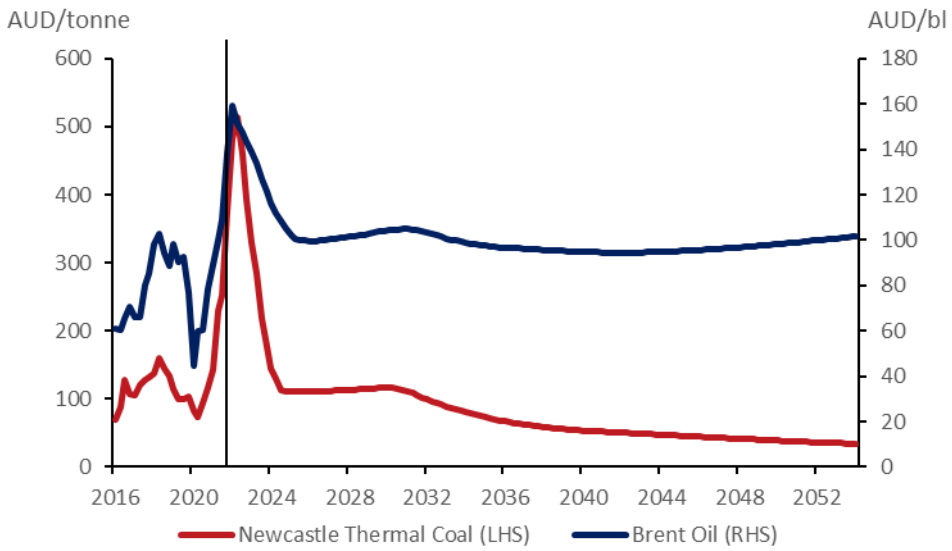
Commodity Price Forecasts: Step Change (June 2022 - 2026)					
	Jun-22	Jun-23	Jun-24	Jun-25	Jun-26
Brent Oil Price (AUD/bl)	159	139	116	102	100
LNG Netback Price (AUD/GJ)	37	34	20	15	15
Newcastle Thermal Coal Price (AUD/tonne)	482	329	145	111	110

Long Term Outlook

The long term forecast is influenced by a policy induced decline in demand as the world decarbonises. As demand progressively falls away, suppliers exit the market in merit order from highest cost producer to lowest cost. This is reflected by a fall back in commodity prices.

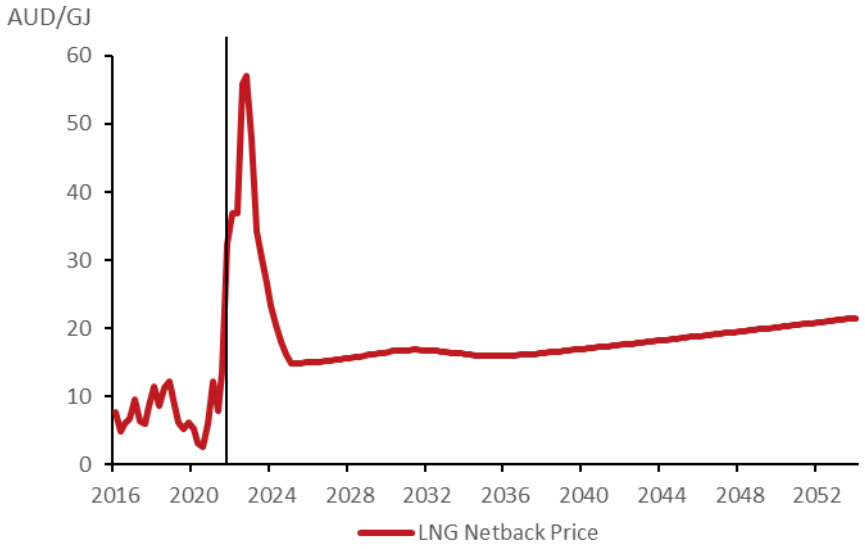
Across the commodities, thermal coal (being the dirtiest of emitters) is the most heavily penalised by the world's decarbonisation efforts. Demand for coal is the fastest to fall away, followed by oil and then LNG, which acts as a transition fuel in the medium term. This is reflected in the long-term profile for these commodities.

Fig. 1. Long-Run Outlook for Newcastle Thermal Coal Price and Brent Crude Oil Price, Nominal



Source: BIS Oxford Economics/ Renewable Energy Quarterly/Haver Analytics

Fig. 2. Long-Run Outlook for LNG Netback Price (Wallumbilla), Nominal



Source: BIS Oxford Economics/ Renewable Energy Quarterly/Haver Analytics

Alternative Scenarios

In addition to the *Step Change* scenario, this report considers three other alternative cases – *Progressive Change, Exploring Alternatives* and *Hydrogen Export*. Each of these represents alternative energy transition pathways.

For each case the following overarching settings are assumed:

- **Progressive Change**: this is a slow economic growth scenario, with weaker population and productivity growth in the long run. There is less global policy coordination and global action is insufficient to achieve net zero emissions. As a result, the world is on a path to 2.6ºC warming by 2100 (RCP 4.5) from pre-industrial levels.
- **Exploring Alternatives**: similar to the *Step Change* scenario, global policy intention is well aligned in this scenario. However, some countries take longer to fulfil their policy commitments. As a result, climate warming reaches 2.0ºC by 2100 (RCP 3.5).
- **Hydrogen Export**: This is a higher growth pathway to the Step Change scenario, with stronger population and productivity growth in the long run. Both Australia and its global counterparts aggressively pursue net zero emissions, limiting global warming to 1.5ºC by 2100 (RCP 1.9). Additionally, Australia focusses investment in development of its hydrogen export sector, becoming a leader in hydrogen exports globally.

Near Term Outlook

There is considerable risk surrounding the economic environment in the near term. Uncertainty remains around the length of conflict in Ukraine; pace of monetary tightening and demand response. Other risks also include the possibility of a COVID outbreak leading China to reinstate strict lockdowns, triggering another round of supply chain disruptions. On the flip side, an earlier abatement of these headwinds could lead to faster corrections in price. That said, we believe the risks are weighted to the upside for commodity prices.

With this in mind, we model the following near-term upside and downside risks to the outlook:

- In the *Progressive Change* scenario war proves more protracted and energy market disruption more severe than in our baseline forecast. With the Russian energy supplies to Europe severely curtailed, oil, gas, and consequently thermal coal prices soar. Against a backdrop of persistently elevated inflation, households' inflation expectations rise and confidence worsens. Central banks around the world (US, ECB) pursue more aggressive monetary tightening to curb inflation. Policy is tighter than *Step Change* by the latter half of the scenario.
- The *Hydrogen Export* scenario is characterised by an early end to the conflict in Ukraine, diminishing energy market disruption and fading coronavirus concerns. With confidence improving, the result is a sharp consumer led global economic recovery, supported by the run down of a large proportion of the substantial household savings accumulated at the height of the crisis.
- The *Exploring Alternatives* scenario assumes the same near-term economic environment as the *Step Change* case.

As a result, in the *Progressive Change* case we see even stronger price growth that take longer to correct, relative to the *Step Change*. By contrast, the *Hydrogen Export* scenario has a faster pace of correction in the near-term. This is in part exacerbated by early and stronger climate policy action, making fossil fuels less attractive.

Commodity Price Forecasts: Alternative Scenarios (% difference from Step Change)							
	Jun-22	**Jun-23**	**Jun-24**	**Jun-25**	**Jun-26**	**Jun-30**	**Jun-54**
Exploring Alternatives							
Brent Oil Price	0%	0%	0%	0%	0%	0%	15%
LNG Netback Price	0%	1%	0%	0%	0%	0%	14%
Newcastle Thermal Coal Price	0%	-3%	-4%	-1%	0%	0%	9%
Progressive Change							
Brent Oil Price	-3%	-10%	19%	13%	6%	7%	63%
LNG Netback Price	0%	73%	95%	35%	21%	16%	75%
Newcastle Thermal Coal Price	-3%	36%	80%	28%	7%	7%	301%
Hydrogen Export							
Brent Oil Price	-3%	-19%	-22%	-26%	-31%	-39%	-24%
LNG Netback Price	0%	-23%	-25%	-27%	-31%	-38%	-22%
Newcastle Thermal Coal Price	-3%	-4%	-1%	-17%	-38%	-60%	4%

Long Term Outcome

In the long-term, in line with their policy narratives, the *Hydrogen Export* scenario sees the fastest fall back in commodity prices. By contrast, prices remain flat or growing in the *Progressive Change* scenario (in nominal terms). The shift away from fossil fuels is delayed in the *Exploring Alternatives* scenario, leaving prices higher than *Step Change* by the end of the forecast horizon.

Across scenarios, thermal coal is the most affected by climate policy, followed by oil and then LNG. In the *Hydrogen Exports* scenario, the drop in all three fossil fuel sources is the most rapid, owing to the strong policy action. LNG plays a much smaller role as a transition fuel.

The reverse is true in *Progressive Change*. There is still some policy action in *Progressive Change*, which limits growth for Coal (the price outlook is flat in nominal terms) but demand remains solid for oil and gas as users substitute from coal to these sources of fuel. As a result, the nominal price of oil and gas continues to grow in the long-run.

1. INTRODUCTION

BIS Oxford Economics was engaged by the Australian Energy Market Operator (AEMO) to produce commodity price scenario forecasts to supplement the economic projections used in their 2022-23 suite of energy outlook reports.

AEMO delivers a range of planning and forecasting publications to inform decision making including the Electricity Statement of Opportunities (ESOO), the Gas Statement of Opportunities (GSOO) and the Integrated System Plan (ISP). The economic forecasts provided in this report are inputs into AEMO's modelling and forecasting processes.

The commodity price projections are developed for scenarios provided by AEMO in their Inputs, Assumptions and Scenarios Report (IASR)[1]. The scenario narratives that underpin the commodity price forecasts have been developed in consultation with AEMO. The forecasts across scenarios are also consistent with the economic projections produced for AEMO.

The commodity price forecasts have been developed using BIS Oxford Economics' proprietary *Global Economic Model* to ensure consistency between global commodity prices and the country level economic outcomes. For more details on the macroeconomic models, please see Appendix B.

This report supplements the commodity price forecasts produced for AEMO.

The report has been structured as follows:

Chapter 2: Outlines the key scenario narratives, including near term assumptions

Chapters 3: Presents the *Step Change* scenario forecasts

Chapters 4: Presents the alternative scenario forecasts

Appendix A: Details BIS Oxford Economics' proprietary global, industry and state models.

Appendix B: Outlines the foreign exchange rate assumptions and methodology.

Appendix C: Details BIS Oxford Economics' methodology for producing Wallumbilla LNG Netback price forecasts and Newcastle Thermal Coal price forecasts.

Appendix D: Provides a comparison of the commodity forecasts to alternative sources

[1] https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp/current-inputs-assumptions-and-scenarios

2. KEY ECONOMIC AND CLIMATE ASSUMPTIONS

This section outlines the key assumptions and near-term narrative supporting our commodities price forecasts for *Step Change* (baseline) and alternative scenarios – *Progressive Change*, *Exploring Alternatives*, and *Hydrogen Exports*. The scenario settings can be summarised as follows:

- **Step Change**: this is the baseline scenario. Global and domestic policy action to mitigate emissions is assumed to be well aligned. All governments worldwide fulfil their announced climate action pledges. As a result, climate warming is limited to 1.8ºC by 2100 (RCP 2.6).
- **Progressive Change**: this is a slow economic growth scenario, with weaker population and productivity growth in the long run. There is less global policy coordination and global action is insufficient. As a result, the world is on a path to 2.6ºC by 2100 (RCP 4.5).
- **Exploring Alternatives**: similar to the *Step Change* scenario, global policy intention is well aligned in this scenario. However, some countries take longer to fulfil their policy commitments. As a result, climate warming reaches 2.0ºC by 2100 (RCP 3.5).
- **Hydrogen Export**: This is a higher growth pathway to the *Step Change* scenario, with stronger population and productivity growth in the long run. Both Australia and its global counterparts aggressively pursue net zero, limited global warming to 1.5ºC by 2100 (RCP 1.9). Additionally, Australia focusses investment in development of its hydrogen export sector, becoming a leader in hydrogen exports globally.

2.1 NEAR TERM ASSUMPTIONS

In the near term, the key themes affecting the domestic and global economic outlook are the Russia-Ukraine conflict, supply chain pressures, government policy, and further COVID-19 disruptions. The severity of these factors will affect the price of commodities going forward.

Recently, a combination of strong demand, ongoing supply chain disruptions and the economic implications from the Russia-Ukraine conflict has resulted in high inflationary pressures domestically and globally. As a result, central banks around the world have responded by aggressively tightening interest rates. We expect these forces to weigh on consumer demand in the near-term, but uncertainty remains around the severity of these forces.

In addition to these factors, China's zero-COVID policy presents a downside risk as further lockdowns will dampen the near-term global economic outlook and reduce demand for Australian exports. Further lockdowns will also prolong global supply chain disruptions.

In the *Step Change* (baseline) scenario, the recent supply-side problems are expected to ease soon, with inflation expected to peak in FY23 before swiftly returning to levels consistent with the Reserve Bank of Australia's (RBA) target. Underpinning this is the assumption that a long military conflict in Ukraine is avoided and thereby ease pressure on commodity prices, particularly for oil, gas and grains. However, there remain some headwinds to the domestic economy as interest rates rise rapidly for the RBA to curb demand-driven inflationary pressure and manage future inflationary expectations. In addition to this, governments are expected to reduce economic stimulus, which will also suppress domestic consumption in the near term. China is expected to continue their zero-COVID policy; however future lockdowns are expected to be better managed and therefore reduce the economic impacts of a COVID resurgence.

Given the uncertainty around the near-term themes, such as the timing and severity of the supply-side problems, it is appropriate to consider various scenarios. The scenarios considered in this analysis includes:

- **Progressive Change**: In this scenario, global and domestic headwinds weigh on economic activity, with high commodity prices and prolonged supply disruptions fuelling inflationary pressures in the near-term.

  The scenario assumes a worsening of the Russia-Ukraine conflict. As a result, Russian supply of gas and oil to Europe comes to an end in H2 2022. Russian oil production recovers in the medium term and converges with *Step Change* amid diversification of exports to other trading partners. However, this leads to energy market disruptions that are broader and more protracted in the near-term, putting upward pressures on inflation expectations globally.

  Strong inflationary pressures and inflation expectations trigger a swift response from central banks, including the RBA, the Federal Reserve and the European Central Bank (ECB), to tighten monetary policy more aggressively compared to *Step Change*. This reduces consumer confidence leading to weaker economic activity, particularly in the Eurozone, and reduces the demand for commodities.

- **Hydrogen Export**: This scenario is an upside to *Step Change*, which sees inflationary pressures ease quickly as global and domestic supply chain disruptions are resolved earlier than expected.

  The *Hydrogen Export* scenario assumes that the Russia-Ukraine conflict comes to an early end. Russian oil exports are higher than in *Step Change*, but still significantly weaker in the near-term compared to pre-war. Nonetheless, this results in a stronger fall in oil prices compared to *Step Change*.

  Amidst diminishing energy market disruptions and fading COVID concerns, an improvement in confidence results in a sharp consumer-led global recovery. However, policy tightening remains a headwind as central banks continue to tame inflation and inflation expectations, though policy rates are expected to peak sooner in the US compared to *Step Change*.

- **Exploring Alternatives**: Near term assumptions for *Exploring Alternatives* are the same as for *Step Change.*

3. COMMODITIES PRICE FORECASTS: STEP CHANGE

This section presents the *Step Change* forecasts for the following commodities:

- Brent crude oil prices
- Newcastle thermal coal prices
- LNG netback prices (Wallumbilla)

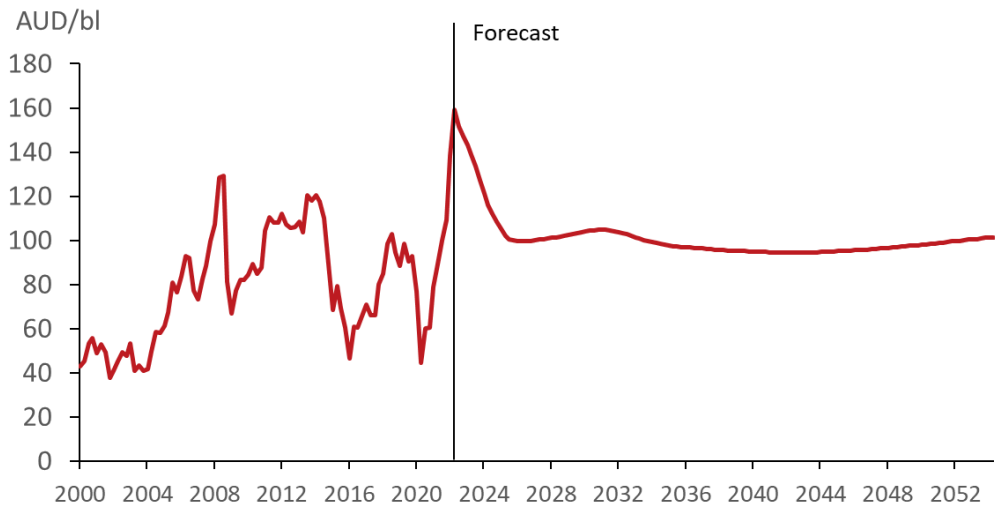
The price forecasts are consistent with the key assumptions and macroeconomic settings for the *Step Change* scenario. In the near term, commodity prices, particularly for oil, gas and grains, are expected to fall from recent highs as an extended military conflict in Ukraine is avoided. Over the medium to longer-term, commodity prices will be driven by the degree of global efforts towards decarbonisation. This scenario assumes relatively strong global coordination towards a greener pathway, which reflects the shifting policy landscape. Domestically, this aligns with Australia's commitment towards net zero by 2050 and we see strong effort towards energy transition investment.

3.1 BRENT CRUDE OIL PRICE FORECASTS

The price of brent crude oil is expected to fall from its peak for the September 2022 quarter as recessionary concerns in major foreign economies weigh on demand. Beyond this, oil prices are expected to fall further with the increase in supply following a ramp up in US production and OPEC's agreement to raise their monthly production quotas. Nonetheless, prices are expected to remain relatively elevated, supported by China's reopening and the recovery in air travel.

In the longer term, the price of crude oil is expected to see little growth, averaging around AUD 98/bl. Underpinning this is a greater coordinated effort towards a greener pathway, including the move toward electric vehicles and sustainable transportation.

Fig. 3. Brent Crude Oil Price, Step Change, Nominal



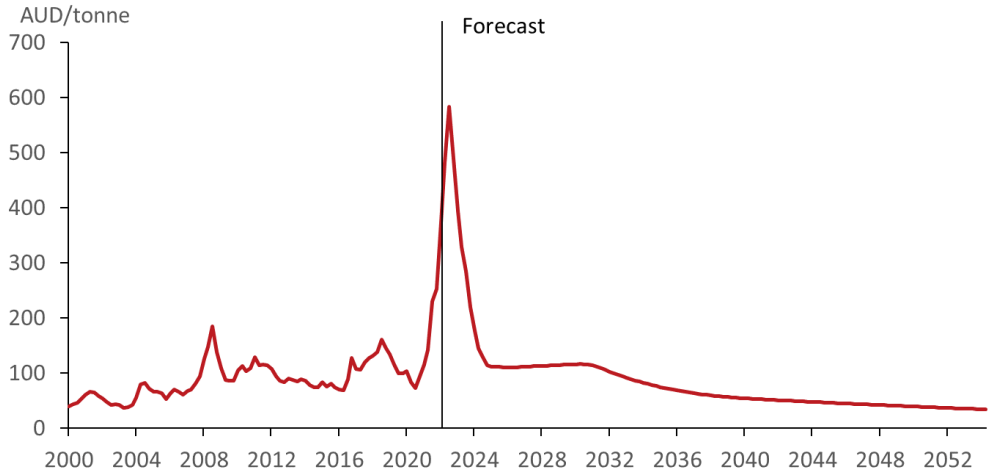
Source: BIS Oxford Economics/Haver Analytics

3.2 NEWCASTLE THERMAL COAL PRICE FORECASTS

The price of Newcastle thermal coal is expected to peak in the September 2022 quarter, at AUD 584/tonne. The recent high prices are driven by strong demand for higher-grade thermal coal, particularly from Japan, South Korea, Taiwan, and to some extent, the EU as these economies seek to end imports from Russia. Prices are then expected to fall relatively quickly as supply-side issues dissipates and energy markets stabilise.

In the longer term, the price of Newcastle thermal coal is expected to decline over time. This follows a reduction in demand as the world decarbonises and thereby transitions away from fossil fuels, particularly in electricity generation.

Fig. 4. Newcastle Thermal Coal Price, Step Change, Nominal



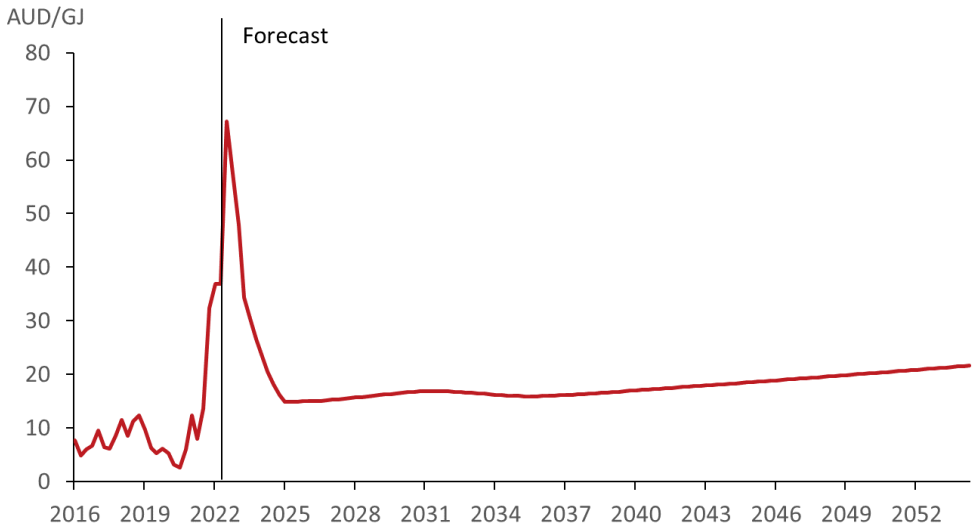
Source: BIS Oxford Economics/ World Bank Commodity Prices/ Resource and Energy Quarterly (Office of the Chief Economist) LNG Netback Price Forecasts

3.3 LNG NETBACK PRICES WALLUMBILLA

The LNG netback price (Wallumbilla) is expected to peak in the September 2022 quarter, at AUD 67/GJ. This is driven by strong global demand for natural gas as well as a reduction in Russian gas supply to Europe. Beyond this, prices are expected fall as supply-side problems fade but remain elevated, particularly during the European winter and spring seasons which lasts until mid-2023.

In the longer term, the LNG netback price (Wallumbilla) is expected to see little growth, averaging at around AUD 18/GJ. This is underpinned by a transition away from the use of LNG in residential buildings and electricity generation.

Fig. 5. LNG Netback Price (Wallumbilla), Step Change, Nominal



Source: BIS Oxford Economics/ACCC Netback Price Forecasts

4. COMMODITIES PRICE FORECASTS: ALTERNATIVE SCENARIOS

This section presents risks to the *Step Change* commodities price forecasts. This was achieved by varying the near-term and longer-term assumptions that underpin the forecasts.

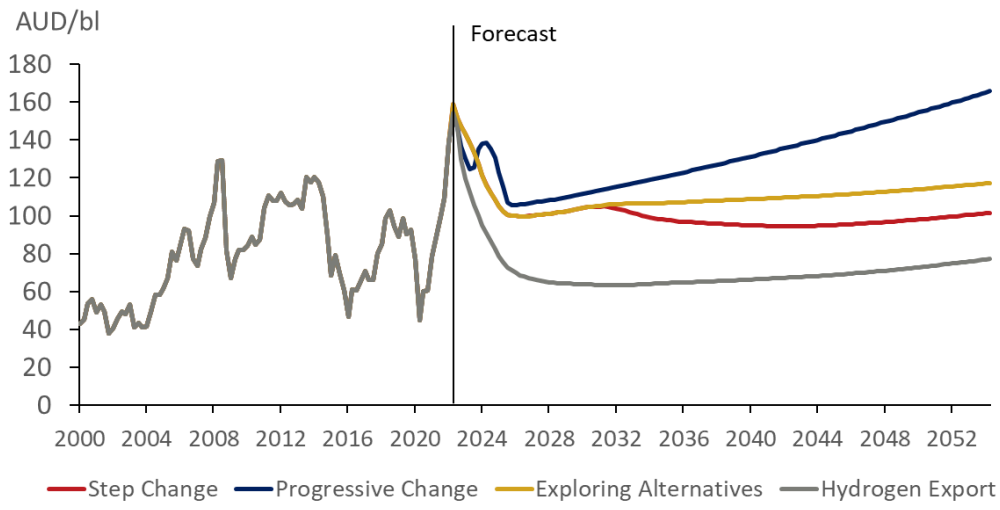
In the near-term, the alternative scenarios capture the uncertainty around the timing of the Russia-Ukraine war, the severity of global supply chain disruptions, and the state of the global economy. In the long term, the alternative scenarios capture the varying degree of decarbonisation efforts at a global and domestic scale, as well as differences in the exchange rates.

4.1 BRENT CRUDE OIL PRICE FORECASTS

In comparison to the *Step Change* scenario:

- **Progressive Change**: Prolonged supply chain disruptions exacerbated by rapidly rising interest rates will result in a contraction of global economic activity in this scenario. This reduces the demand for crude oil and sees prices fall to levels that are below *Step Change* over the coming year. However, a prolonging of the Russia-Ukraine conflict will likely drive oil prices higher in the medium term, with oil prices peaking at around AUD 139/bl in 2024. In the long term, the price of crude oil is expected to remain higher than in *Step Change* due to a greater reliance on fossil fuels and a weakening exchange rate against the US dollar
- **Hydrogen Export**: Energy market disruptions ease swiftly following an early end to the Russia-Ukraine conflict. This results in a sharp fall in crude oil prices in the near term, reaching below pre-pandemic levels by early 2024. Beyond this, the price of crude oil is expected to remain below that of *Step Change* due to lower demand for fossil fuels. In the long term, prices are further lowered by a stronger Australian dollar relative to the US dollar.
- **Exploring Alternatives**: The near-term assumptions are the same. However, the price of crude oil is higher in the long term, reflecting weaker global action towards decarbonisation compared to *Step Change*.

Fig. 6. Brent Crude Oil Price, All Scenarios, Nominal



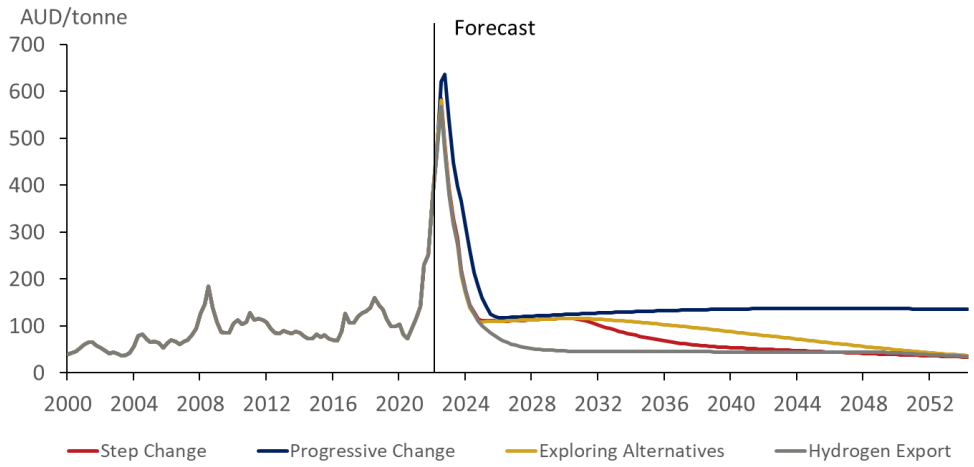
Source: BIS Oxford Economics/Haver Analytics

4.2 NEWCASTLE THERMAL COAL PRICE FORECASTS

The disruption from the Russia-Ukraine war is expected to largely impact oil and gas prices. That said, Russia is also one of the largest global exporters of coal. While sanctions on Russian coal are starting to take effect in some European countries and Japan, others have stepped in to take advantage of the unwanted supply. The result for global prices is that the trade uncertainty created from the war in Ukraine is adding another factor to support higher coal prices – in what is already an inflated market. As a result, there is potential for Newcastle thermal coal prices to continue rising in the short term as captured by the *Progressive Change* scenario. In the medium to long term, prices begin to diverge more across scenarios as the different assumptions on climate change actions kick in.

- **Progressive Change**: Continued coal trade disruption and the high price of LNG leads to an increase in demand for thermal coal, particularly for high-grade thermal coal. As a result, the price for Newcastle thermal coal is expected to peak in December 2022 and remain relatively higher in the near term. In the medium to long term, thermal coal prices are expected to remain relatively flat and remain higher than *Step Change*. This is driven by relatively stronger global demand for thermal coal despite domestic decarbonisation efforts.
- **Hydrogen Export**: This scenario sees the fastest decline in the price of thermal coal, reaching its long-term equilibrium price of around AUD 53/tonne by 2030, a few years before *Step Change*. This reflects both a more aggressive fading out of coal as well as earlier and greater investment towards clean energy.
- **Exploring Alternatives**: This scenario is similar to *Step Change*, except that there is a lag in decarbonisation targets globally, albeit to a lesser degree than *Progressive Change*. Therefore, the price of thermal coal falls much slower compared to *Step Change* and remains slightly higher in the long term.

Fig. 7. Newcastle Thermal Coal Price, All Scenarios, Nominal



Source: BIS Oxford Economics/ World Bank Commodity Prices/ Resource and Energy Quarterly (Office of the Chief Economist)

4.3 LNG NETBACK PRICE (WALLUMBILLA) FORECASTS

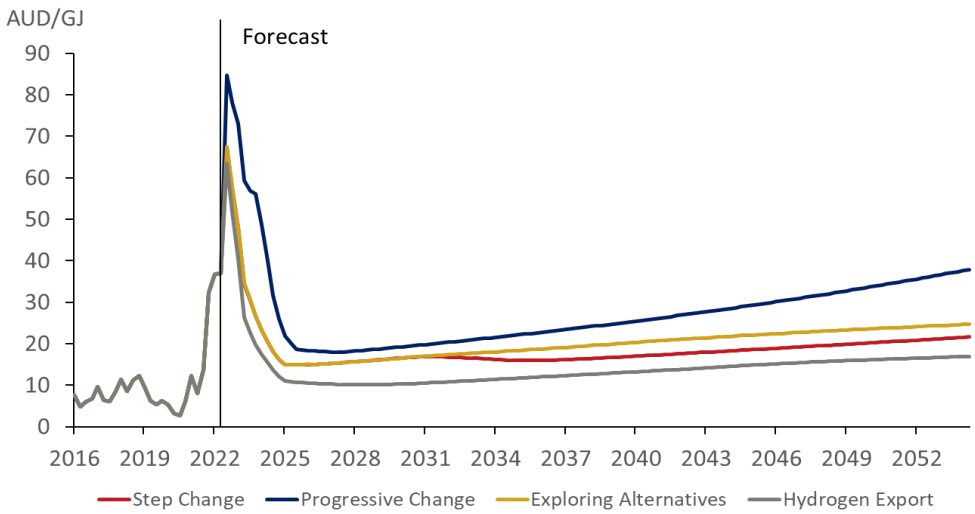
In comparison to the *Step Change* scenario:

- **Progressive Change**: The LNG netback price (Wallumbilla) is expected to peak higher in the September 2022 quarter, at around AUD 85/GJ, due to a prolonging of the war in Ukraine.

Prices are expected to remain elevated for longer and diverge further in the long term due to slower decarbonisation progress.

- **Hydrogen Export**: There is little divergence with *Step Change* until around mid-2023 as the demand for gas remains strong globally. Beyond this, prices begin to unwind faster as energy markets stabilise following the end of the Russia-Ukraine conflict.
- **Exploring Alternatives**: There is no divergence in prices in the near to medium term as the assumptions are the same. In the long term, prices are expected to remain relatively flat, but above *Step Change*, reflecting the lags in decarbonisation targets globally.

Fig. 8. LNG Netback Price (Wallumbilla), All Scenarios, Nominal



Source: BIS Oxford Economics/ACCC Netback Price Forecasts

APPENDIX A: OXFORD ECONOMICS GEM MODEL FORECASTS

This section provides an overview of Oxford Economics Global Economic Model which underpin our global macro forecasts.

Global Economic Model

The Oxford Global Economic Model (GEM) is the most widely used commercial International Macro Model, with clients including international institutions, Ministries of Finance and central banks around the world, and a large number of blue-chip companies. In addition, the GEM is used internally within Oxford Economics, for both baseline forecasting and simulating alternative scenarios for the world economy and individual economies.

The GEM has constantly evolved over the past three decades, reflecting continuous interaction between the Global Economic Model and changing conditions in the policy sphere, private sector, and global institutions. It is intended for use both by Oxford Economics and by clients to produce forecasts for a wide range of international macroeconomic and related variables, and for "what-if" scenario analysis. Clients can produce forecasts using the model either with a detailed internal forecasting exercise or simply by taking the Oxford Economics baseline and adjusting a small number of key inputs/assumptions. Scenario analysis can focus on the expected impact of a particular event or policy change or cover a wider range of alternative outcomes for stress testing.

It has long been one of Oxford Economics' guiding principles that many of the most important and interesting macroeconomic issues are inherently international. Globalization means that policy makers and analysts must form judgements about developments in their domestic economy and in the economies of countries with which they have trade and financial ties. For instance, a shift in US monetary policy has global repercussions; fossil fuel and commodity price shocks are significant source of terms of trade movements in Europe; governments increasingly collaborate over monetary, fiscal and environmental policies. These stylized facts imply that single country econometric models, which treat world trade, world prices and exchange rates as exogenous, are not best suited to analysing some of the most important issues of interest to financial and business economists.

The root cause of this integration is the massive increase in trade and capital flows between countries in the post-war period, and Oxford Economics' client base is testament to the growth in interest in international issues. With offices throughout the world, in the UK, elsewhere in Europe, the US and Asia, Oxford Economics aims to combine access to local information and expertise with a global outlook to provide a truly international service. The Oxford Global Economic Model reflects this priority, as coverage of the major trading countries has deepened and widened.

The current Oxford Model improves on previous vintages by incorporating descriptions of 80 individual countries. The model is "well-behaved" in the sense that it has a coherent long-run equilibrium embedded which the model will tend to converge to in the long run for a wide range of sensibly calibrated shocks.

It maintains the tradition of allowing for significant cross-country differences in economic structure, but ensures that those differences truly reflect economic, as opposed to economic model-builders', idiosyncrasies. Where possible, and it is possible in the majority of cases, the functional form for equations is left the same across countries. The exceptions chiefly reflect examples where countries are heavily dependent on particular sectors such as oil and emerging market countries where Foreign Direct Investment (FDI) plays a major role in the economy. Where the data allow, some countries have more detail on trade, distinguishing fuel and non-fuel and modelling profit and dividend receipts.

Parameters across countries differ, and this means that different countries exhibit different behaviour in response to shocks (although economy structure also accounts for variations). Now, however, tracing the root cause of these differences, and attributing them to underlying behaviour or structure, is much simpler. For instance, real wage rigidity is higher in some countries than others, and specific coefficients in wage and price equations reflect this. Unemployment will tend to rise further and faster in these countries in response to an adverse demand shock, even though the functional form of wage and price equations is identical across countries.

Structure of the GEM

Very broadly, the Oxford Global Economic Model is Keynesian in the short-run and monetarist in the long-run. This means that increased demand will lead to higher output and employment initially, but eventually this feeds through into higher wages and prices. Given an inflation target, interest rates have to rise, reducing demand again ('crowding out'). In the long run, output and employment are determined by 'supply side' factors. Interactions between countries through trade, exchange and interest rates, capital flows and oil/commodity prices are modelled in detail.

Within this theoretical framework, the structure of each country in the Oxford Global Economic Model can be generalized as follows:

- Consumption - function of real income, wealth and interest rates.
- Investment - 'q' formulation with accelerator terms.
- Exports - depend on world demand and relative unit labour costs.
- Imports - depend on total final expenditure and competitiveness.
- Real wages depend on productivity and unemployment relative to NAIRU.
- Prices are a mark-up on unit costs, with profits margins a function of the output gap.
- Monetary policy endogenised. Options include Taylor rule, fixed money and exchange rate targeting.
- Exchange rate determined by uncovered interest parity (UIP) in the short run and equilibrium exchange rates in the long run.
- Expectations are generally adaptive, with an option to use forward-looking expectations on a model-consistent basis for certain key financial variables.
- Countries are linked in the Oxford Global Economic Model via:
- Trade (Exports driven by weighted matrix of trading partners' import demand).
- Competitiveness (IMF relative unit labour costs where available, relative prices elsewhere).
- Interest Rates and Exchange Rates.
- Commodity Prices (e.g. oil, gas and coal prices depend on supply/demand balance; metal prices depend on growth in industry output).
- World Price of Manufactured Goods.

Country model detail

The structure of each of the country models is based on the income-expenditure accounting framework. However, the models have a coherent treatment of supply. In the long run, each of the economies behaves like the classic one sector economy under Cobb-Douglas technology (production function). Countries have a natural growth rate, which is determined by capital stock, labour supply adjusted for human capital, and total factor productivity. Output cycles around a deterministic trend, so the level of potential output at any point in time can be defined, along with a corresponding natural rate of unemployment.

Firms are assumed to set prices given output and the capital stock, but the labour market is characterized by imperfect competition. Firms bargain with workers over wages but choose the optimal level of employment. Under this construct, countries with higher real wages demonstrate

higher long-run unemployment, while countries with more rigid real wages demonstrate higher unemployment relative to the natural rate.

Inflation is a monetary phenomenon in the long run. All of the models assume a vertical Phillips curve, so expansionary demand policies place upward pressure on inflation. Unchecked, these pressures cause an unbounded acceleration of the price level. Given the negative economic consequences of this (as seen in the 1970s in developed economies and more recently in some emerging markets), most countries have adopted a monetary policy framework which keeps inflation in check. The model mirrors this, by incorporating endogenous monetary policy. For the main advanced economies, monetary policy is underpinned by the Taylor rule, captured using an inflation target, such that interest rates are assumed to rise when inflation is above the target rate, and/or output is above potential. The coefficients in the interest rate reaction function, as well as the inflation target itself, reflect assumptions about how hawkish different countries are about inflation. (A by-product of this system is that scenarios under fixed interest rates only make sense in the short run. A scenario which imposes a fixed interest rate, and therefore assumes a lack of monetary policy, in conjunction with a vertical Phillips curve, would result in accelerating - or decelerating - inflation after several years.)

Demand is modelled as a function of real incomes, real financial wealth, real interest rates and inflation. Investment equations are underpinned by the Tobin's Q Ratio, such that the investment rate is determined by the return relative to the opportunity cost, adjusted for taxes and allowances. Countries are assumed to be "infinitely small", in the sense that exports are determined by aggregate demand and a country cannot ultimately determine its own terms of trade. Consequently, exports are a function of world demand and the real exchange rate, and the world trade matrix ensures adding-up consistency across countries. Imports are determined by real domestic demand and competitiveness.

Expectations

The Oxford Global Economic Model standard mode assumes adaptive rather than forward looking expectations because we believe that introducing expectations on the basis of economic theory is more advantageous than using the forward-looking assumption ubiquitously. There is disagreement among economists about whether forward looking expectations are consistent with observed data, which become even more acute in light of the difficulties with obtaining accurate data on expectations for model-building purposes. Instead, we generally adopt adaptive expectations, which are introduced using a framework in which expectations are formed using the actual predicted values from the model. Exogenous variables are assumed to be known a priori. Where appropriate, the model does introduce expectations implicitly and explicitly, therefore accounting for how and the extent to which agents respond to information about changes in fundamentals. An example of this includes our derivation of exchange rate forecasts which implicitly capture expectations: in the short run, the exchange rate is driven by movements in domestic interest rates relative to the US, therefore accounting for uncovered interest rate parity. Another example is our use of a variable for forward guidance to capture expected movements in interest rates. In addition, there is an option to use forward-looking expectations explicitly on a model-consistent basis for certain key financial variables.

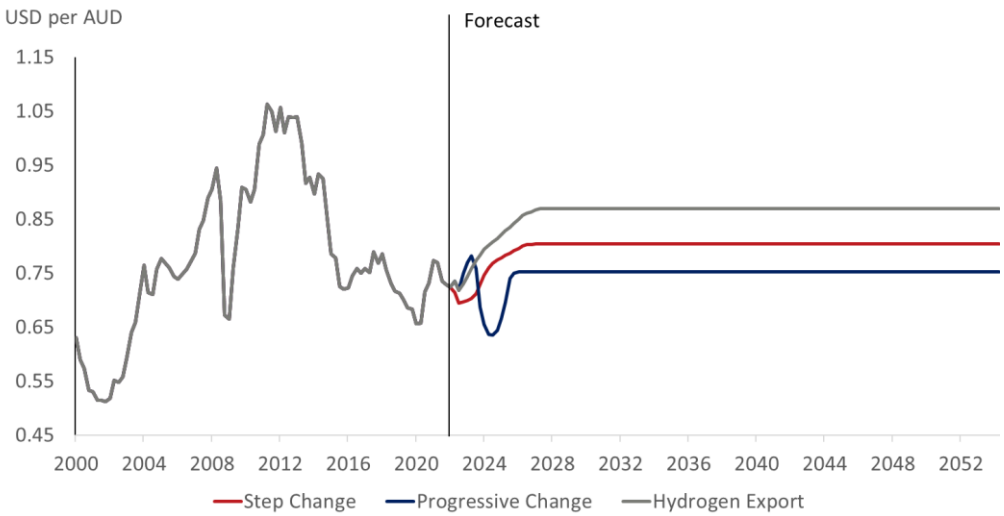
APPENDIX B: FOREIGN EXCHANGE RATES

This section highlights the different AUD/USD exchange rate (FX) profiles across the scenarios. Movements in the AUD is generally influenced by a combination of commodity prices and the general health of the local and global economy. The *Step Change* FX profile is consistent with the BIS Oxford Economics' baseline view, which sees the exchange rate fall in the near term as energy market disruptions ease and is expected to settle at around 0.80 USD per AUD in the long term. The *Exploring Alternatives* scenario follows the same profile as in *Step Change* due to broadly similar economic settings.

The *Progressive Change* scenario presents a down-side risk to economic growth. In the near term, disruptions in the energy market from the Russia-Ukraine conflict creates strong demand for commodities, supporting Australian commodity exports and therefore the AUD. The AUD is expected to peak in late 2023 before falling below its long-run equilibrium rate as global activity slows. The long-run exchange rate is lower than in *Step Change*, at 0.75 USD per AUD, reflecting a weaker domestic economy relative to the US.

In contrast, the *Hydrogen Export* scenario sees the AUD sitting higher at 0.87 USD per AUD in the long run. This is driven by a combination of Australia's new hydrogen exporting industry and strong global activity and consumption, which places upward pressure on the exchange rate.

Fig. 9. Foreign Exchange Rates (AUD/USD), All Scenarios, Nominal



Source: BIS Oxford Economics / Haver Analytics

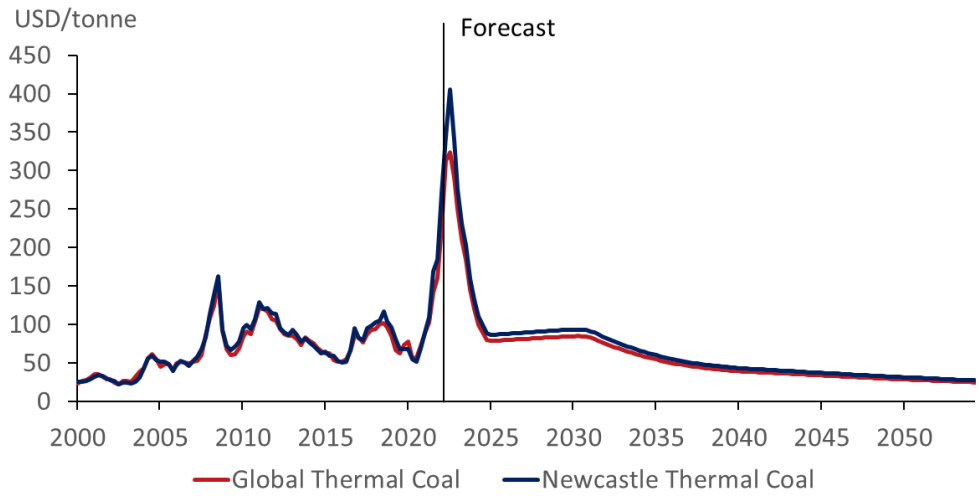
APPENDIX C: ESTIMATING NEWCASTLE THERMAL COAL AND LNG NETBACK PRICE

The scenarios presented in this report are built using the Global Economic Model (GEM), which have commodity price variables such as the global price of thermal coal and LNG JKM prices. These series are then transformed to estimate the Newcastle thermal coal prices and the LNG Netback prices (Wallumbilla). This section provides greater detail on the methodology used to determine these prices

C.1 Newcastle Thermal Coal

The prices of Newcastle thermal coal have tracked global prices of thermal coal very closely in the past and this relationship is expected to maintain going forward for the *Step Change* (baseline) scenario. Therefore, we apply the growth rates of global thermal coal prices to the most recent price estimates for Newcastle thermal coal. We also note that prices for the June and September 2022 quarters are estimated separately. The June 2022 price is an estimate taken from the Office of the Chief Economist's Resources and Energy Quarterly Forecast Data. While the September 2022 price is an estimate based on the near-month futures contract for Newcastle coal in July and August, which is a close proxy for the spot prices over that period.

Fig. 10. Global vs Newcastle Thermal Coal Prices, Nominal



Source: BIS Oxford Economics/ World Bank Commodity Prices/ Resource and Energy Quarterly (Office of the Chief Economist)

C.2 LNG Netback Price

The LNG netback price is the effective price that LNG producers can expect to receive for exported LNG after applicable costs are subtracted from the LNG price. These costs are generally incurred in the transportation stage between the gas production wells and an LNG processing facility.

The LNG netback price series provided in this report is derived based using the ACCC's methodology[2]. The following steps outline this process:

1. **Starting with the LNG JKM price series**: the BIS Oxford Economics model (GEM) provides a forecast of the LNG JKM price measured in USD/Mmbtu.
2. **Obtaining the Gladstone free-on-board (FOB) price**: Freight costs between Gladstone's export terminal and Japan/Korea are then subtracted. Here, BIS Oxford Economics used ACCC's estimates holding freight costs (on average) at 2.7% of the commodity price. This is effectively the LNG Netback price at the export terminal.
3. **Converting to AUD/GJ**: The FOB price series is then converted into AUD/GJ. This uses the BIS Oxford Economics' foreign exchange model and the ACCC's Mmbtu to GJ conversion assumptions.
4. **Netting back LNG plant costs**: The Gladstone FOB prices (in AUD/GJ) is then subtracted by plant costs provided by the ACCC. "*The ACCC use estimates of short-run marginal LNG plant costs (averaged across Queensland LNG producers). These costs include the value of the gas that is consumed as fuel during the liquefaction process as well as LNG plant operating expenditure.[3]"*
5. **Adjust for transportation costs from well-head to export facility**: Finally, the series is then subtracted by the ACCC's estimate of short-run marginal transport costs between the wellhead and the LNG facility in Wallumbilla (averaged across the Queensland LNG producers).

[2] *LNG Netback Prices*, ACCC, https://www.accc.gov.au/regulated-infrastructure/energy/gas-inquiry-2017-2025/lng-netback-price-series

[3] *Guide to the LNG Netback Price Series,* ACCC, *https://www.accc.gov.au/sites/www.accc.gov.au/files/Guide%20to%20the%20LNG%20netback%20price%20series%20-%20September%202022.pdf*

APPENDIX D: BENCHMARKING

This section provides a comparison of BIS Oxford Economics' commodity price forecasts against alternative sources of forecast. The main objective of this section is to assess how the *Step Change* (central case) forecast developed by BIS Oxford Economics' sits relative to other outlooks in the market.

This chapter is structured in two parts. The first part compares the near-term profile, which is dictated by the assumptions around current developments such as timing of the end of the war in Ukraine and pace of monetary tightening by central banks around the world. The second part compares the long-run trajectory, which is primarily determined by the decarbonisation pathway.

For this exercise, BIS Oxford Economics has relied on independent forecasts from the following sources:

- Consensus Economics forecasts survey (August, 2022)[4]
- Office of the Chief Economist (OoCE), *Resources and Energy Quarterly (REQ) –June 2022*
- Australian Competition & Consumer Commission (ACCC)
- International Energy Agency (IEA)

SHORT-TERM FORECAST BENCHMARKING

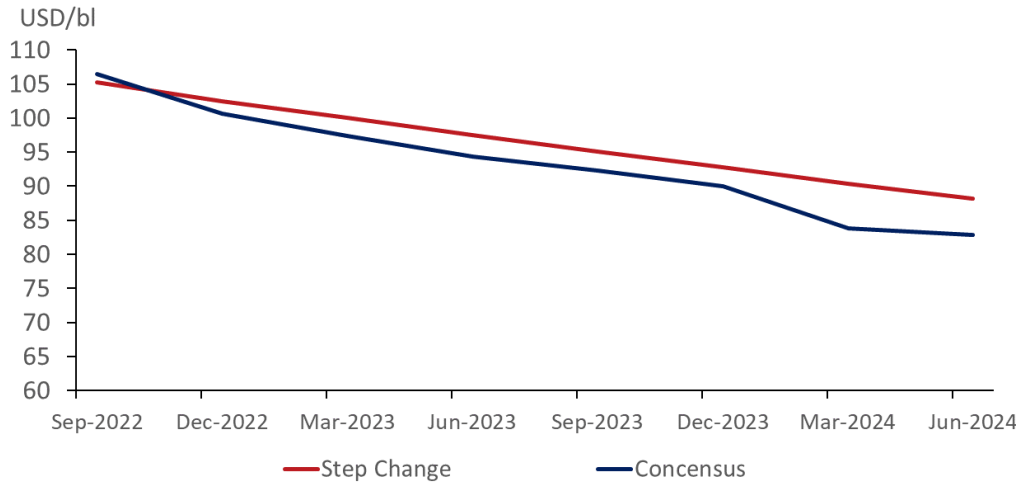
Generally, across all commodities, the *Step Change* forecasts are well aligned with market consensus in the near term. In the case of Newcastle Thermal Coal Prices and the LNG Japan-Korea Marker (JKM), BIS Oxford Economics expects a slightly faster pace of correction in the prices from their currently elevated levels. This is primarily underpinned by the assumptions that the Russia-Ukraine conflict and general supply-chain bottlenecks will ease in the next few quarters.

Brent Oil Price

The *Step Change* projections are well aligned with the market consensus forecasts. Market consensus expects prices to fall back slightly faster (USD $82.8/bl by Mar-24 compared with USD $88.1 in *Step Change*.

[4] Consensus Economics is an international economic survey organisation that polls economic forecasters, covering both public and private institutions. The Consensus Economics forecasts represent the mean forecasts from the survey results.

Fig. 11. Brent Crude Oil Price (Nominal): BIS OE Step Change vs. Alternative Sources



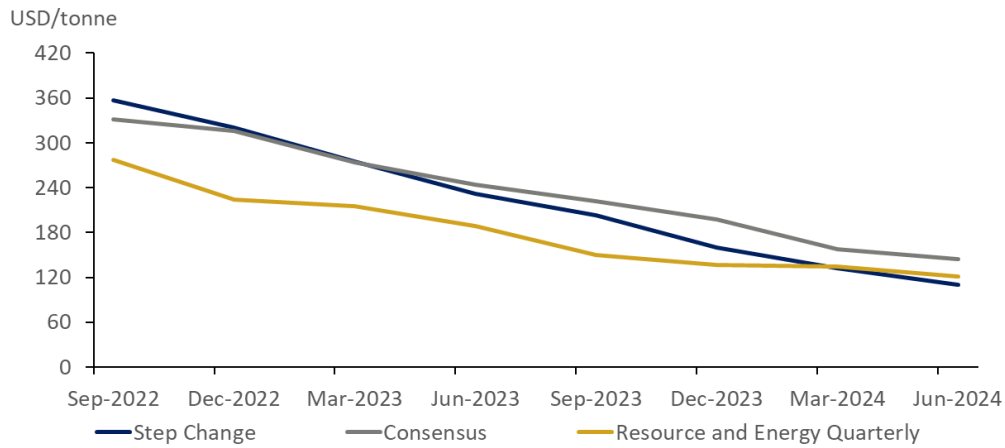
Source: BIS Oxford Economics/ Consensus

Newcastle Thermal Coal Forecasts

For the Newcastle Thermal Coal Forecasts, the figure below provides a comparison against market consensus as well as the Office of the Chief Economist's forecasts published in their *Resource and Energy Quarterly* report.

The *Step Change* projections are generally well aligned to market consensus over the next 12 months. *Step Change* forecasts sit within 1% of market consensus forecasts over this period. Beyond this, *Step Change* includes a faster pace of correction with prices falling to USD $110/tonne compared to USD $145/tonne for market consensus. This largely reflects BIS OEs assumptions around the timing of easing of supply constraining factors, such as the Russia-Ukraine conflict and supply chain bottlenecks as well as weakening demand in response to monetary policy tightening measures.

Fig. 12. Newcastle Thermal Coal Price (Nominal): BIS OE Step Change vs. Alternative Sources



Source: BIS Oxford Economics/ Consensus/ Resource and Energy Quarterly (Office of the Chief Economist)

Both the market consensus forecasts and the *Step Change* forecasts sit consistently above the OoCE projections in the near term. By the end of this forecast horizon, *Step Change* is closer to OoCE forecast (USD $121/tonne, March-24).

The near-term differences in profiles, we expect, are owing to a difference in timing of when the forecasts were developed. There have been strong upward movements in the price of thermal coal over the last month driven by strong demand for higher-grade thermal coal, particularly from Japan, South Korea, Taiwan, and to some extent, the EU as these economies seek to end imports from Russia.

Fig. 13. Newcastle Thermal Coal Price (Nominal): Daily Historical Prices

Source: BIS Oxford Economics/ Haver Analytics

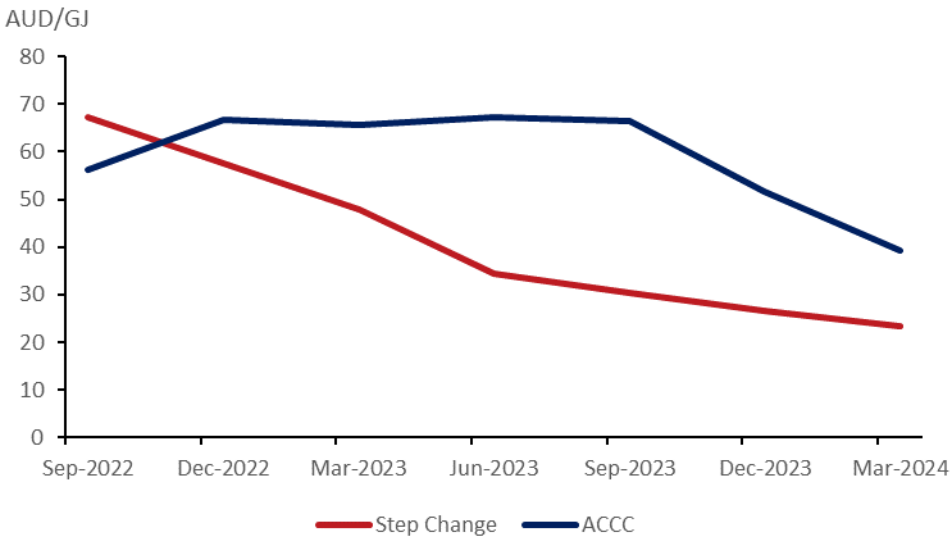
LNG Netback Price Forecasts

For the Wallumbilla LNG Netback Price there are limited projections publicly available to benchmark against. Below we provide a comparison of *Step Change* projections to ACCC's published August 2022 outlook.

We note that the *Step Change* forecasts for the Sep-22 quarter are stronger than ACCC's outlook. However, beyond this *Step Change* projects a much faster pace of correction than ACCC.

ACCC expects the current elevated prices to be sustained until late 2023, before beginning to correct.

Fig. 14. LNG Netback Price (Wallumbilla), Nominal: BIS OE Step Change vs. Alternative Source



Source: BIS Oxford Economics/ ACCC

Delving into this further, two key components that determine the LNG Netback Price are the LNG Japanese Korea Marker (JKM) price, which is the reference spot market price for the Asian market, and the exchange rate.

For these individual components, market consensus forecasts are available and so we provide below a comparison of *Step Change*, ACCC and market consensus forecasts for these individual sub-components of the LNG Netback Price.

LNG Japanese Korea Marker

As Fig. 15 shows, the ACCC projections are markedly stronger than both *Step Change* projections and market consensus forecasts.

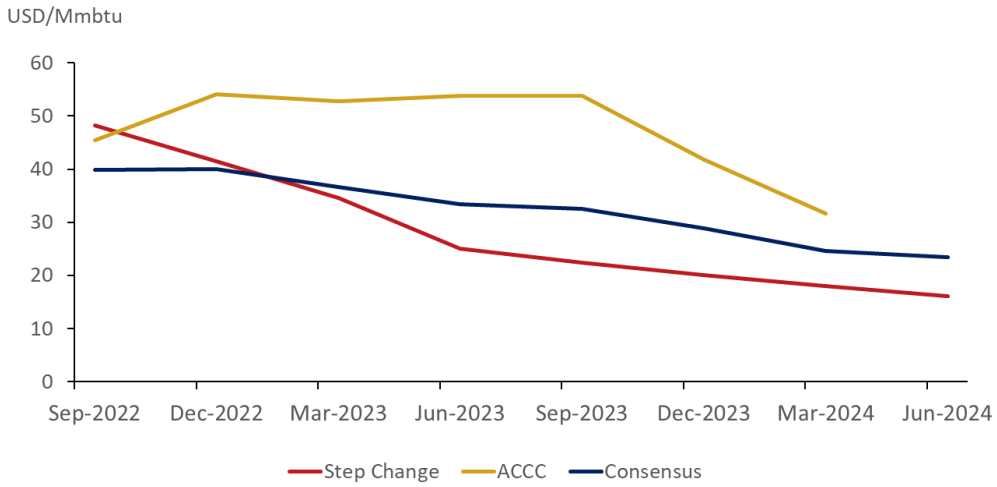
This is the main driver of difference between *Step Change* projections and ACCC projections for the final LNG Netback Price[5].

Step Change and Consensus projections are well aligned until Mar-2023. *Step Change* projections have a faster fall back beyond this, expecting the LNG JKM price to get back to USD $16.1/Mmbtu by June-24 compared with market consensus of USD $23.5/Mmbtu.

Again, this is underpinned by our assumptions around unwinding of current supply side pressures. We also note, as recent data highlights, that commodity price movements are subject to considerable volatility and that uncertainty on the price trajectory increases over time.

[5] The assumptions for Plant Operating Costs; Transport & Freight Costs and Plant Efficiency are sourced from the ACCC (https://www.accc.gov.au/regulated-infrastructure/energy/gas-inquiry-2017-2025/lng-netback-price-series) . Please see Appendix C for more details on calculating final LNG netback price.

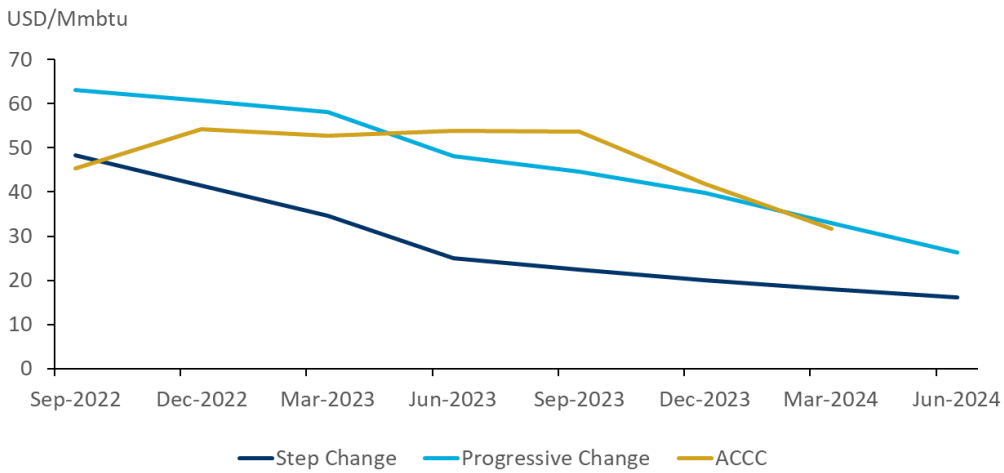
Fig. 15. LNG JKM Price (Nominal): BIS OE Step Change vs. Alternative Sources



Source: BIS Oxford Economics/ Consensus/ ACCC

While the ACCC forecasts are higher than what our view is of the most likely path for this market, we note that ACCC's projection sits within the range of alternate scenarios that we have considered, as shown in Fig. 16.

Fig. 16. LNG JKM Price (Nominal): BIS OE Progressive Change vs. ACCC projections

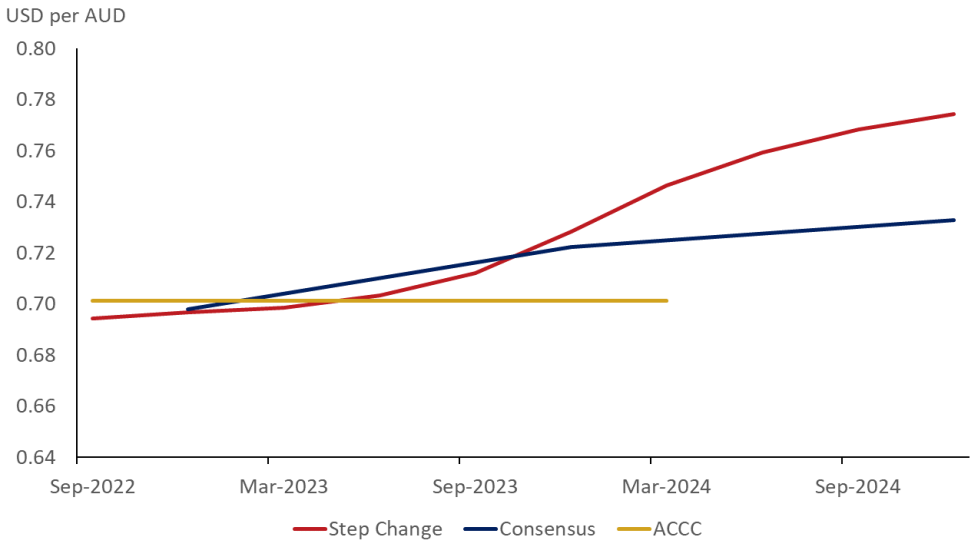


Source: BIS Oxford Economics/ ACCC

Exchange Rate Forecasts

Exchange rate forecasts is a secondary source for difference between ACCC and BIS OE projections for final LNG Netback Price. As we can see from the chart below, ACCC assumes a constant exchange rate of USD:AUD 0.70. By contrast, Step Change expects the Australian dollar to appreciate, sitting at USD:AUD 0.77 by Dec-24. Consensus is slightly lower, at USD:AUD 0.73 by Dec-24.

Fig. 17. Exchange Rate Forecast (Nominal): BIS OE Step Change vs. Alternative Sources



Source: BIS Oxford Economics/ Consensus/ ACCC

LONG-TERM FORECAST BENCHMARKING

The long run outcomes across scenarios are largely determined by the assumptions on global commitments to decarbonisation.

This is important for the commodities presented here as it dictates the pace of structural shift in demand away from emissions intensive fossil fuels. We assume that as demand falls away under these alternative scenarios, the highest cost (least competitive) suppliers of fossil fuels are the first to exit the market. As such, the price of the marginal supply of fossil fuels falls, which is then reflected in the commodity prices.

There is limited information available to benchmark against for the long-run scenario forecasts. That said, the AEMO scenario settings broadly align to the IEA scenarios as follows

Fig. 18. AEMO to IEA Scenario Mapping

AEMO Scenario	IEA (World Energy Outlook 2021) Scenario
Step Change	Sustainable Development Goal (SDS)
Progressive Change	Stated Energy Policies (STEPS)
Hydrogen Export	Net Zero Emissions (NZE)
Exploring Alternative Scenario	Announced Pledges Scenario (APS)

We provide here a comparison of the AEMO scenario results to projections from the International Energy Agency (in their *2021 World Energy Outlook*), by commodity.

Given the material developments in the commodity markets since the *2021 World Energy Outlook (WEO)* was published, it is more useful to focus on the trends rather than the price levels. As such the discussion in this section is centred on the trends.

Brent Oil Price Projections

In the medium term (2020-2030) BIS Oxford Economics projections are broadly aligned across scenarios. The exception here is *Progressive Change*, in which IEA projects stronger price growth.

Over the long-run (to 2050), the *Hydrogen Export* scenario projections are well aligned to IEA's *Net Zero Emissions* scenario forecasts. In the other scenarios, the commodity price forecasts developed for AEMO's scenarios generally reflect a stronger fall in real prices.

Fig. 19. Brent Crude Oil Price (2020 Real): BIS Oxford Economics and IEA

Brent Oil Price (Real USD/bl)	2020	2030	2050
Step Change			
BIS OE	41.8	59.2	32.8
IEA (Sustainable Development)	42.0	56.0	50.0
Progressive Change			
BIS OE	41.8	59.3	48.4
IEA (Stated Policies)	42.0	77.0	88.0
Exploring Alternatives			
BIS OE	41.8	59.8	35.8
IEA (Announced Pledges)	42.0	67.0	64.0
Hydrogen Export			
BIS OE	41.8	36.3	24.2
IEA (Net Zero Emissions by 2050)	42.0	36.0	24.0

Source: BIS Oxford Economics/Haver Analytics, IEA

World Gas Price Projections

The IEA publish projections for the Japanese gas import price. This isn't directly comparable to the LNG netback price or the LNG JKM however these indicators are closely linked (especially over the long-term). That is why we have included a comparison to these gas prices, as a useful reference.

BIS Oxford Economics' *Global Economic Model* also produces projections for Japanese gas import prices. This has been used in the comparison to the IEA projections as shown in the table below. These forecasts are consistent with the LNG price projections, across scenarios.

As the table below shows, AEMO's scenario projections are well aligned to IEA's projections across all scenarios over the outlook, both in the medium term (to 2030) and the long-term (to 2050).

Fig. 20. Japanese Gas Prices (Real, 2020 terms): BIS OE vs. IEA

Japanese gas price (Real USD/MBtu)	2020	2030	2050
Step Change			
BIS OE	8.3	9.2	6.6
IEA (Sustainable Development)	7.9	5.4	5.3
Progressive Change			
BIS OE	8.3	10.0	10.3
IEA (Stated Policies)	7.9	8.5	8.9
Exploring Alternatives			
BIS OE	8.3	9.3	7.2
IEA (Announced Pledges)	7.9	7.6	6.8
Hydrogen Export			
BIS OE	8.3	5.6	5.1
IEA (Net Zero Emissions by 2050)	7.9	4.4	4.2

Source: BIS Oxford Economics/Haver Analytics, IEA

Coal Price Projections

For thermal coal prices, the IEA reports prices for US, EU, Japan and Coastal China. These figures are not directly comparable to Newcastle Thermal Coal prices. However, it is still useful to compare overall trends across these markets.

Please note that trends in an individual thermal coal market may also be influenced by substitution across these markets, in addition to structural shifts across the entire sector.

For example, if much of the early coal production exits in a decarbonisation scenario are concentrated in the US market, then this may see a surge in demand for other markets which would temporarily lift

prices in those markets as well. Over the long run, we would expect to see a fall back in prices consistently across markets.

In the comparison to the AEMO scenario projections, over the medium term the trends are broadly similar. The *Hydrogen Export* scenario is the exception where only the US market has sharp price falls while the other markets have a gradual decline. We note that the IEA global coal demand however is broadly consistent with BIS Oxford Economics for this scenario. IEA projects a 50% decline in demand by 2030 while BIS Oxford Economics forecasts a 60% decline. Given this sharp fall to demand, in our view a more pronounced fall in price is a consistent outcome.

Fig. 21. Thermal Coal Prices (Real, 2020 terms): BIS OE vs. IEA

Steam Coal Price (Real USD/tonne)	2020	2030	2050
Step Change			
BIS OE (Global weighted average)	65.9	59.6	11.7
IEA (Sustainable Development)			
US	43.0	24.0	22.0
EU	50.0	58.0	55.0
Japan	69.0	67.0	63.0
Coastal China	89.0	72.0	66.0
Progressive Change			
BIS OE (Global weighted average)	65.9	60.1	38.7
IEA (Stated Policies)			
US	43.0	39.0	38.0
EU	50.0	67.0	63.0
Japan	69.0	77.0	70.0
Coastal China	89.0	83.0	74.0
Exploring Alternatives			
BIS OE (Global weighted average)	65.9	60.4	13.7
IEA (Announced Pledges)			
US	43.0	25.0	25.0
EU	50.0	66.0	56.0
Japan	69.0	73.0	63.0
Coastal China	89.0	77.0	65.0
Hydrogen Export			
BIS OE (Global weighted average)	65.9	24.0	12.5
IEA (Net Zero Emissions by 2050)			
US	43.0	24.0	22.0
EU	50.0	52.0	44.0
Japan	69.0	58.0	50.0
Coastal China	89.0	61.0	51.0

Source: BIS Oxford Economics/Haver Analytics, IEA

Over the long-run (to 2050), across all scenarios, AEMO's scenario price forecasts continue to fall at a faster rate than IEA. The IEA note that "*In the much more constrained demand environment of the APS and even more so the NZE (where no new coal mines or mine extensions are required) prices simply gravitate towards the operating costs of existing projects.*[6]"

[6] Chapter 2, *World Energy Outlook 2021*, October-21, https://www.iea.org/reports/world-energy-outlook-2021

This is consistent with the overall approach that BIS Oxford Economics takes, which assumes that as demand progressively falls away, suppliers exit the market in merit order from highest cost to least cost and long-term prices broadly reflect marginal cost of supply.

While it is difficult to ascertain the exact cause of difference between the two sources of forecasts, we are comfortable that the long-run price projections presented in this report consistently reflect the supply and demand dynamics.

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