Danish Energy Agency

MOIT

EREA
Electricity & Renewable Energy Authority

EMBASSY OF DENMARK
Hanoi

Fuel Price Projections

Background to Vietnam Energy Outlook Report 2019

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1 Introduction

This report is part of the Danish Energy Agency's (DEA) Energy Partnership Programme between Viet Nam and Denmark (DEPP). The activity is part of the development engagement "Capacity Development for long-range energy sector planning with Electricity and Renewable Energy Agency of Vietnam (EREA)".

The activities include model-based analyses about the possible long-term development of the Vietnamese power sector. The Balmorel model computes least-cost development, including optimal investments in new power generation capacity. This is a continuation of earlier work, e.g. presented in the Energy Outlook Report 2017 (MOIT and DEA, 2017).

Least-cost development of the power sector is heavily dependent on assumptions regarding a series of aspects:

- Energy demand prognoses (analysed in a separate report)
- Future technology costs for generation (a technology catalogue is being developed for Vietnam based on similar analyses from Indonesia and Denmark).
- Future fuel prices (this report)

Short-term fuel prices have historically shown large variations, and this has also been reflected in considerable variations in long-term prognoses. While it is impossible to accurately predict future fuel prices, the purpose of this report is to suggest a consistent method, and to understand the uncertainty related to fuel price predictions.

In Denmark, the Danish Energy Agency bases expectations about future fuel prices on analyses from the International Energy Agency (IEA), e.g. (IEA, 2017, a). In Vietnam, estimates of future fuel prices have been based on analyses from the World Bank (WB), e.g. (World Bank, 2018a). Another source of price prognosis is (EIA, 2018).

The purpose of this report is to provide a consistent methodology for the estimation of international and domestic fuel prices relevant in the Vietnamese context, to be used as inputs to the long-term energy sector modelling of the DEPP programme activities. The report only takes IEA and WB fuel price prognoses into account as basis for long-term fuel price projections as these two are the current sources used by the governments of Vietnam and Denmark.

The report compares the IEA and WB fuel price prognoses, discusses the methods used and suggests prices to be used for imported and domestic oil, coal, LNG and biomass (2020 – 2050).

2 Price and methodology overview

The world has experienced large price variation in key fuel prices, e.g. for oil (see Figure 1-1).

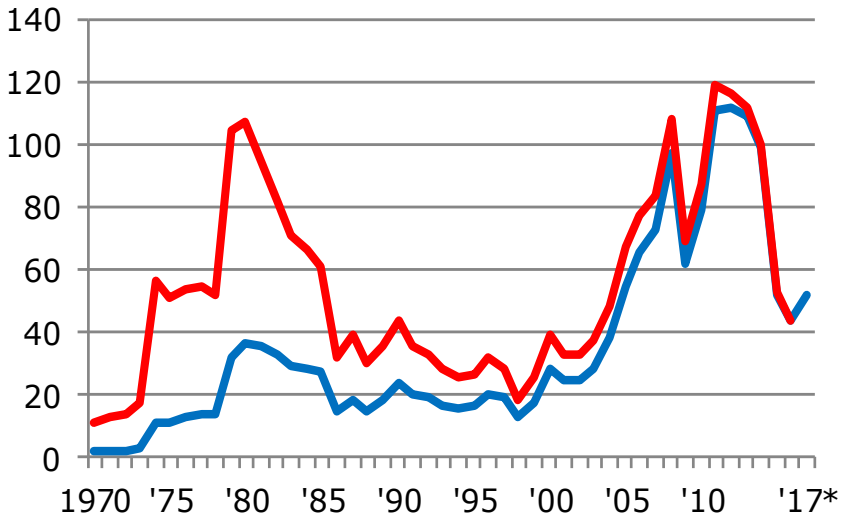

Figure 1-1. Historical oil prices (USD/barrel). Upper curve (red) in real 2016 USD. Lower curve (blue) in nominal value (USD). DEA (2018).

2.1 World Bank – Commodity price forecasts

Methodology

The latest World Bank energy commodity prices are presented in a report entitled 'Commodity Markets Outlook' from April of 2018, which includes analyses, historical prices, short-term and long-term price forecasts for a broad range of over 40 commodities within energy, agriculture, fertilizers, metals, minerals and precious metals (World Bank, 2018a). In the near term (until 2021) the prices are given for each year. After that prices are given for 2025 and 2030.

The World Bank has been undertaking commodity price forecasts since 1994, with past annual publications varying between 0-4 per year, many of which are freely available on their website (Wold Bank, 2018b).

The World Bank report briefly outlines some risks and tendencies related to the various energy commodities, but there is no description of the methodology used for the price forecasts[1].

[1] The authors of the current report have contacted a number of individuals from the World Bank, including the commodities section, but the only additional information received was that the forecasting is carried out by their research department.

Price forecasts

The World Bank price forecasts for 5 energy products in nominal and constant US dollars are displayed in Figure 1-2 below.

Commodity	Unit	2015	2016	2017	Forecasts 2018	2019	2020	2021	2025	2030
Energy										
Coal, Australia	$/mt	57.5	65.9	88.4	85.0	75.0	65.0	64.5	62.4	60.0
Crude oil, avg	$/bbl	50.8	42.8	52.8	65.0	65.0	65.4	65.9	67.7	70.0
Natural gas, Europe	$/mmbtu	7.26	4.56	5.65	6.50	6.61	6.73	6.85	3.56	4.00
Natural gas, U.S.	$/mmbtu	2.61	2.49	2.96	3.03	3.10	3.17	3.25	9.89	10.00
Natural gas, Japan	$/mmbtu	10.22	6.89	8.04	8.80	8.95	9.10	9.25	9.9	10.0

Commodity	Unit	2015	2016	2017	Forecasts 2018	2019	2020	2021	2025	2030
Energy										
Coal, Australia	$/mt	58.8	70.0	90.9	88.0	76.2	64.9	63.3	57.2	50.3
Crude oil, avg	$/bbl	51.9	45.5	54.3	67.3	66.0	65.3	64.7	62.0	58.7
Natural gas, Europe	$/mmbtu	7.42	4.85	5.80	6.73	6.72	6.72	6.72	6.72	6.71
Natural gas, US	$/mmbtu	2.67	2.65	3.04	3.14	3.15	3.17	3.19	3.26	3.35
Natural gas, Japan	$/mmbtu	10.44	7.33	8.27	9.11	9.03	8.98	8.92	8.69	8.39

Figure 1-2: World Bank energy commodity price forecasts. Upper table in nominal US dollars, lower table in constant US dollars (2010). (World Bank, 2018a). Note that the World Bank's constant prices are deflated by a Manufacturers Unit Value (MUV).

The World Bank utilises a Manufacturers Unit Value (MUV) index to arrive at real prices (lower portion of Figure 1-2). This differs from standard inflation indexation, where the MUV is the unit index in US dollar terms of manufactures exported from 15 countries as opposed to standard inflation indexing. It was elected to use the World Bank nominal prices (the upper portion of Figure 1-2) and apply a standard inflation indexation to arrive at prices in 2016 USD for use in further analysis. However, in reviewing the World Bank nominal price forecasts it became apparent that there is an error regarding the price forecasts for US and European natural gas in 2025 and 2030. It is likely that the Japanese price appears where the US price should be; the US price appears where the European price should be; as a result there is no nominal price forecast for US natural gas during 2025 and 2030. The authors of this report have therefore utilised the relationship between coal and crude oil prices in the World Bank's nominal and real price forecasts to determine these missing natural gas values[2].

The Australian coal price in the above figure is a FOB[3] price, while the oil price is an average of Brent, Dubai Fetch, and WTI prices (Table 1). With respect to natural gas, the European price is an average import price, the US price is a Henry Hub spot price, and Japanese price is the LNG import price. Table 1 below provides more fuel specific details.

[2] The full set of 2010 USD prices were then converted to 2016 USD prices based on historic inflation rates (Statista, 2018).

[3] FOB: free on board, simple stated, the price of the commodity once it has been loaded on a ship.

Commodity	Specifications
Coal (Australia)	Thermal, fob. piers, Newcastle/Port Kembla, 6,700 kcal/kg, 90 days forward delivery.
Crude oil, avg.	Average price of Brent (38° API), Dubai Fateh (32° API), and West Texas Intermediate (WTI, 40° API). Equally weighed.
Natural gas, Europe	Average import border price with a component of spot price, including UK.
Natural gas, US	Spot price at Henry Hub, Louisiana.
Natural gas, Japan	LNG, import price, CIF[4]; recent two months' averages are estimates.

Table 1: World Bank energy commodity specifications (World Bank, 2018a).

After correcting a perceived error in the World Bank data (see footnote 2), the resulting prices for all 3 fuels (coal, crude oil and natural gas) are displayed in Figure 1-3 and Figure 1-4 below.

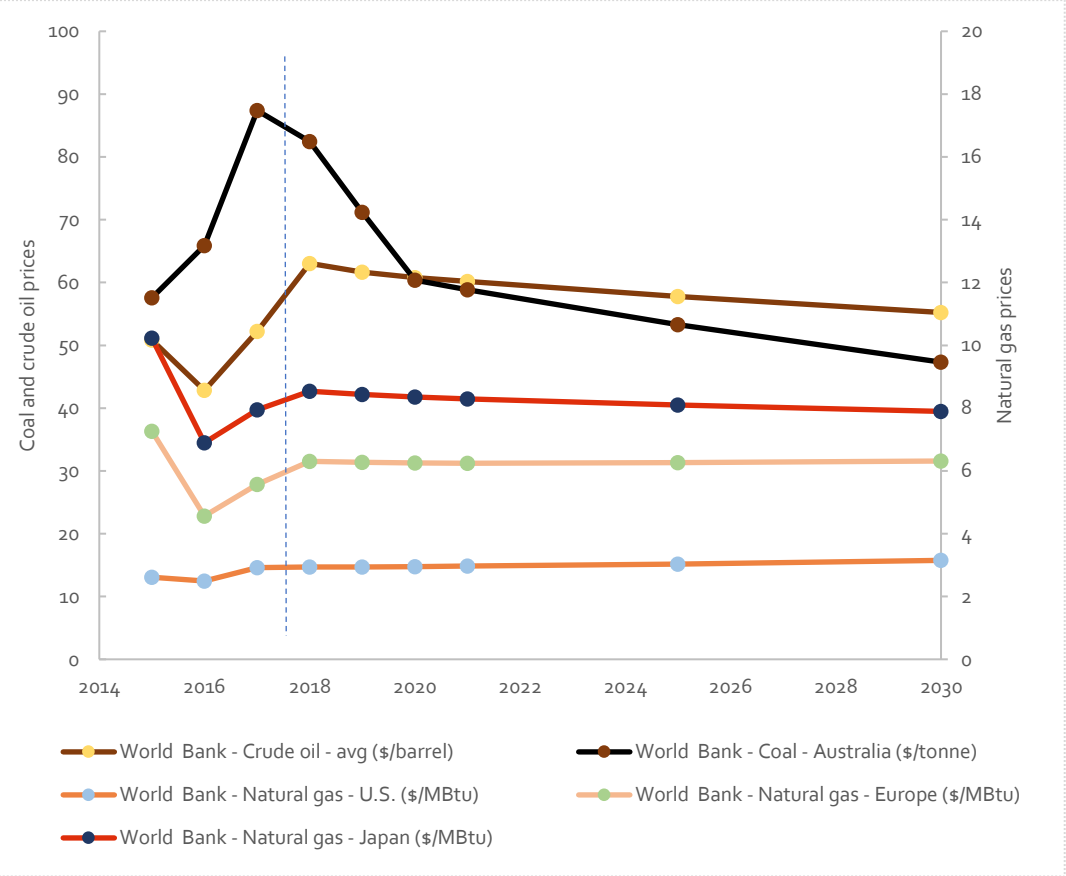

Figure 1-3: Fossil fuel price forecasts in 2016 USD based on World Bank forecast prices ($/trade units). Note that natural gas is on the right axis. Dots represent years with data points.

[4] CIF: Cost Insurance and Freight, simply stated, the price of a commodity on a ship (prior to offloading) on arrival in a harbour.

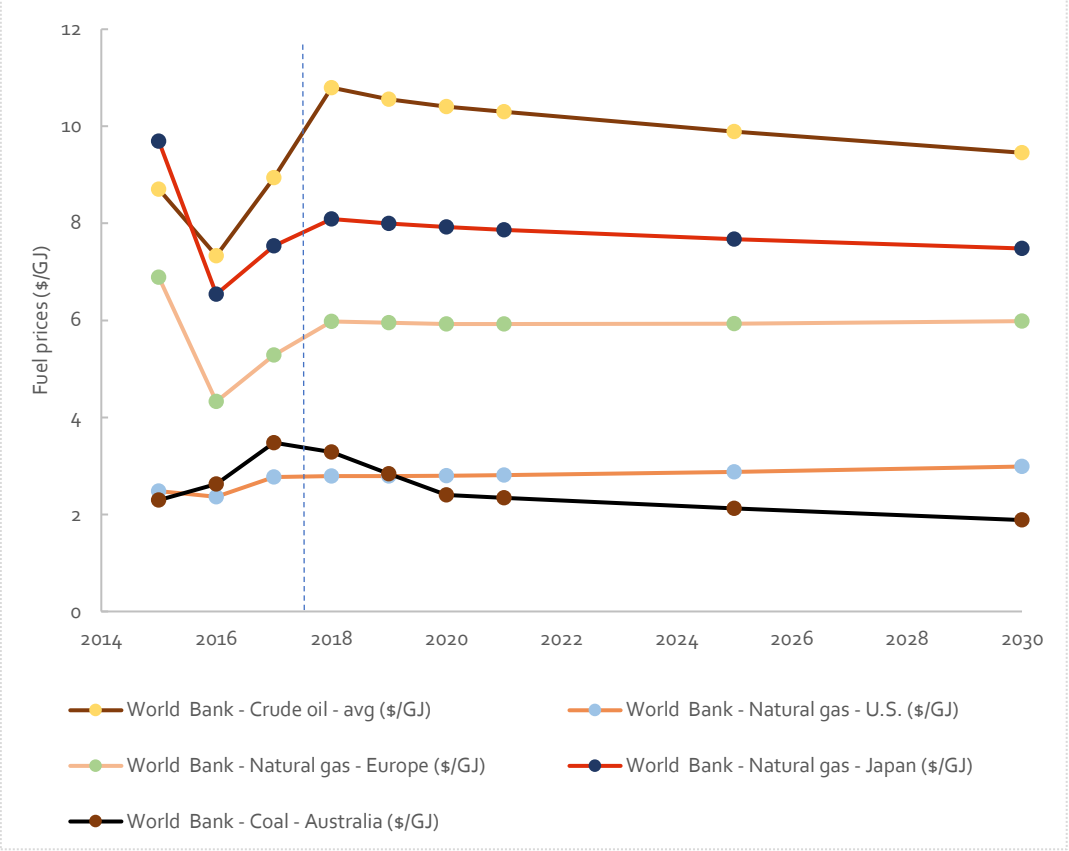

Figure 1-4: Fossil fuel price forecasts in 2016 USD/GJ based on World Bank forecast prices ($/GJ). Dots represent years with data points.

With respect to natural gas, the World Bank forecasts anticipate a slight fall in Japanese import prices, and slight increases in US and European prices relative to today. For oil, the World Bank forecasts a price fall of over 12% in 2030 relative to 2018, while the forecasted price fall for coal is over 43%, with the steepest decline anticipated in the next 2 years. All price estimations are quite constant after 2020.

2.2 IEA World Energy Outlook

Methodology

Each November the IEA publishes its annual World Energy Outlook (WEO), a comprehensive report providing in-depth scenario analysis of the energy sector. The main tool used in the development of the WEO scenario projections is the World Energy Model (WEM), which according to the extensive publicly available background documentation, is a "large-scale simulation model designed to replicate how energy markets function and is used to generate detailed sector-by-sector and region-by-region projections" (IEA, 2017, b).

The WEM operates under the assumptions of long-term equilibrium, i.e. a state of the economy where the general price level is fully reflecting and ad-

justed to the existing set-up of the main price drivers and market factors (as opposed to short-term equilibrium or cyclicality where the price level might not be fully adjusted to the current situation in the market due to different short-term market factors and distortions/ fluctuations).

The WEO traditionally has three primary scenarios and a number of alternative scenarios. The three main scenarios in the most recent WEO are:

- *Current Policies Scenario* - This scenario only factors in the impacts of policies and measures that were in place as of mid-2018, and therefore does not incorporate the influence of any new potential legislation or policies. The IEA states that this scenario can be seen as a "cautious assessment of where momentum from existing policies might lead the energy sector in the absence of any other impetus from government" (IEA, 2018, b). The scenarios can be considered as "unrealistic conservative".
- *New Policies Scenario* - This scenario attempts to paint a future picture of the energy sector based on the current policy ambitions. It therefore incorporates both currently implemented policies and measures around the world, but also the *anticipated effects* of announced policies and measures, which would for example include National Determined Contributions (NDC) under the Paris Agreement.
- *Sustainable Development Scenario* – This is a new scenario that made its debut in the 2017 WEO and according to the IEA, "outlines an integrated approach to achieving internationally agreed objectives on climate change, air quality and universal access to modern energy" (IEA, 2018, b).

All of the WEO scenario projections operate under the assumption of long-term equilibrium subject to fundamental supply and demand dynamics, i.e. effects of short-term market volatility and fluctuations are not a part of the price pathways of the sensitivity analysis. As in any modelling framework, the World Energy Model simplifies reality, and the assumptions undertaken have a significant impact on the results. The validity of the long-term price projections set forth in the WEO scenarios are subject to the materialisation of the assumptions and dynamics (e.g. assumption of long-term equilibrium) underlying the said scenario.

Price forecasts

The WEO provides fuel price forecasts for a number of different regions. For natural gas and coal, separate price forecasts are provided for the United States, the European Union, China, and Japan. In this section prices from the

WEO 2017 are shown, since these will be most comparable to those projected by World Bank as they originate from the same year. The 2017 WEO price forecasts for international oil, US coal and US natural gas are displayed in Figure 1-5.

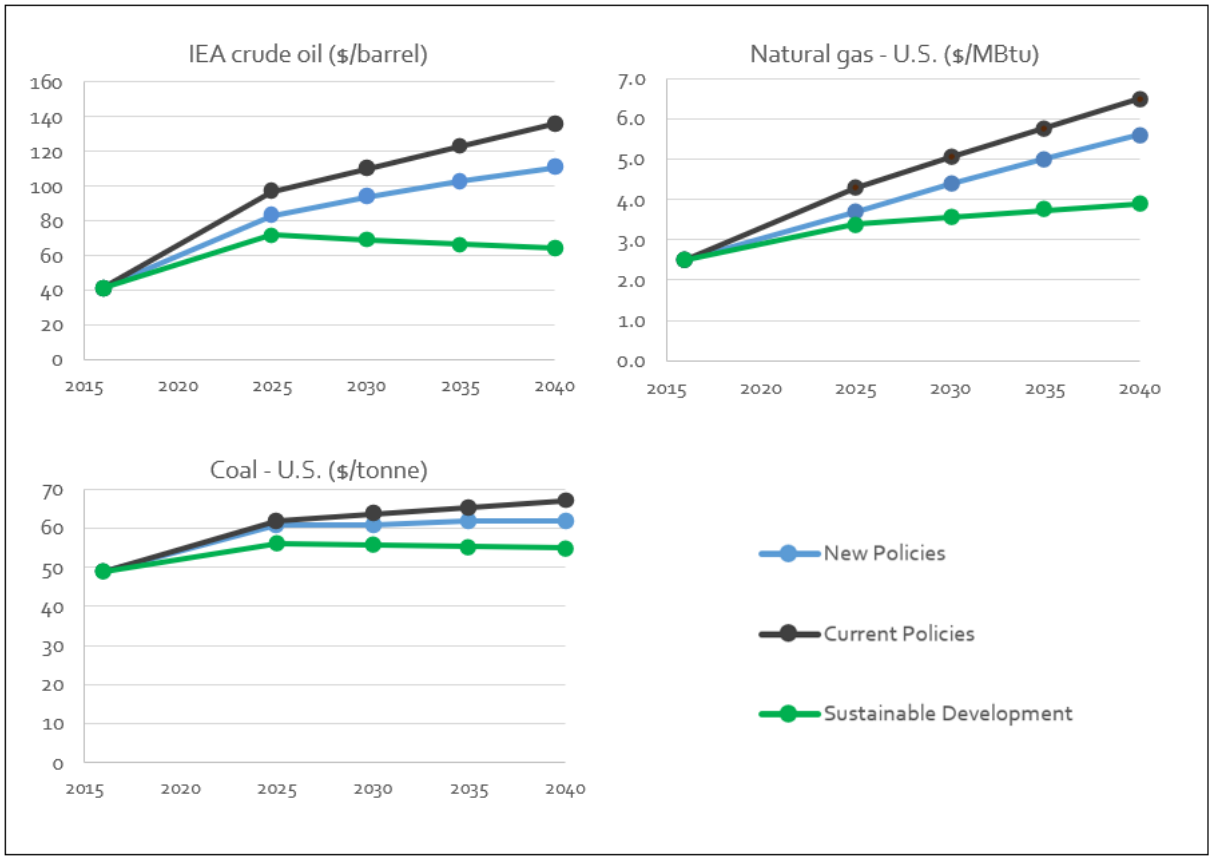

Figure 1-5: Fossils fuel prices from the IEA's 2017 version of the World Energy Outlook. All values are in 2016 USD (IEA, 2017, a). Dots represent years with data points.

In terms of the fuel specifics in Figure 5:

- The IEA crude oil price is a weighted average import price among IEA member countries.
- The US steam coal price reflects mine-mouth prices (primarily in the Powder River Basin, Illinois Basin, Northern Appalachia and Central Appalachia markets) plus transport and handling cost.
- The US gas price reflects the wholesale price prevailing on the domestic market.

As can be seen from the figure, all three fossil fuels are forecasted to have the highest price in the Current Policies scenario, followed by the New Policies scenario, and the lowest prices in the Sustainable Development scenario. This is due to the assumed climate policy initiatives in each of the scenarios, with

the Current Policies scenario having the least ambitious climate change mitigation policies in place, and the Sustainable Development scenario having the highest. With more aggressive climate change mitigation policies in place it is assumed that demand for fossil fuels will fall, and thereby the price will fall.

Ea Energy Analyses' utilisation of IEA prices

The following section presents and discusses how Ea Energy Analyses (Ea) undertakes work with long-term price prognoses. Part of this work has been financed by the Danish Energy Agency.

For its long-term fossil fuel price projections, Ea takes its point of departure in the above-described IEA scenarios. For the majority of Ea's analysis work it is necessary to have one main set of fuel prices, and these fuel prices shall reflect what Ea deems to be the *most likely* scenario going forward. The fuel prices in Ea's main scenario are therefore *not* meant to reflect a frozen policy, nor business as usual future, but instead an *anticipated development* future.

Core scenario selection

For a number of years, Ea utilised the central of the 3 scenarios (the New Policies Scenario) but starting with the 2015 WEO Ea shifted over to using the 450 PPM scenario (similar to the Sustainable development scenario today). This was done because at the time it was assessed that the fossil fuel price predictions arising from the New Policies Scenario were simply too high relative to what Ea deemed the *most likely* scenario, e.g. in the 2015 WEO, the price forecast for coal in 2040 was roughly 110 USD/tonne in the New Policies Scenario vs. the 2017 WEO which had a 2040 price of roughly 80 USD/tonne (see Figure 1-13). In addition, Ea found that the IEA consistently underestimates both the cost reductions and rollout of renewable technologies, which points to a future more in line with the WEO Sustainable Development scenario. The costs of renewables have decreased drastically in recent years, as demonstrated by record low RE auction prices in Mexico, as well as low prices in Dubai, Peru, Chile, Abu Dhabi and Saudi Arabia (IRENA, 2018). At the same time, a number of countries that until recently had plans for massive investments in coal going forward have begun to cut back drastically on these plans. A prominent example includes India, which has seen its coal-fired pre-construction project pipeline reduced by 24 GW in the last six months alone (IEEFA, 2018). Taking all these elements into consideration, Ea considered the WEO Sustainable Development scenario to be the most likely of the three. However, it should be noted that Ea's shift away from New Policies scenario came at a time when the New Policies price forecasts for natural gas and coal where considerably higher than those from the 2017 WEO (see Figure 1-12 and Figure 1-13 in a later chapter). Therefore, relative to when the WEO 2015 edition

was released, Ea would be more inclined today to use the New Policies scenario as the main scenario.
In order to arrive at prices that both reflect Danish consumption points, as well as capture short-term price fluctuations and volatility, Ea has developed a method that builds on the IEA prices comprising two main steps:

- Converging the IEA projections with Forward/Future contract prices in the short- to medium-term to better express the current market expectations.
- Estimating price add-ons to transform the IEA prices into Danish consumer prices over the course of the projection period.

Methodology and rationale for price convergence
Due to the market volatility of energy prices and the time lag between the date of the IEA finalising its fuel price inputs and when the WEO is published, as well as the moment when Ea undertakes its fuel price projections for use in analysis, market prices may have changed (particularly for short-term deliveries). It is therefore reasonable to apply the WEO price projections in the medium to long-term based on fundamental supply and demand dynamics (subject to the realisation of the assumptions regarding these dynamics in the respective scenarios). In the short- to medium-term, on the other hand, it is reasonable to assume that price projections based on the best available actual market information would be more representative (thereby likely incorporating the price effects of short-term market distortions and/or cyclicality).

This gives rise to a need for a simple and transparent methodology for combining the long-term energy price projections from the last IEA publication with the most recent market view provided by forward prices. There is no single robust scientific method for doing so, thus a pragmatic and transparent approach which generates conceivable outcomes was developed. This approach involves utilising the latest forward/futures prices for each energy commodity and converging these prices towards the future applicable WEO scenario prices. During the initial timeframe, the future/forward prices receive a 100% weighting in the estimated price, and this percentage gradually falls to zero when the WEO scenario becomes the sole driver of the price forecast.

Methodology for fuel price "add-on"
Since the Danish 'at-consumption' prices need to be linked directly to the international derived price forecasts, the methodology employed to determine Danish prices is based on an evaluation of the historical linkages and

comparative levels between Danish wholesale and IEA-based prices, which are CIF prices. Additionally, the price add-ons for each fuel must cover the entire spread between Danish prices at consumption and IEA-based prices. This includes all real costs, as well as trade margins in the supply chain where they occur. While some of these can be substantiated individually, others – particularly trade margins – arise from the difference in price levels, e.g. wholesale vs. retail prices. For this reason, the most important sources of information used to derive the total add-ons are observed prices along the supply chain. The difference in price levels along the supply chain are referred to as 'price spreads'. The difference between wholesale and CIF prices is either found via a bottom-up approach where each component of the price spread is calculated/estimated, or by applying a historical price spread between the two. The selection of approach is dependent on availability of information for each commodity.

In order to ensure consistency and a transparent, straight-forward approach, the add-ons are quantified based on simple historic averages (unless otherwise specified, e.g. in the case of refinery spreads for petroleum products). The only modification applied is with respect to the length of the historic period used in estimation of the averages.

Danish energy agency's utilisation of IEA prices

As Ea Energy Analyses has assisted the Danish Energy Agency in developing their price projection method, the two methods are very similar and follow the same approach consisting of converging short-term forward prices to the IEA prices in the longer term, and adding a fuel add-on to arrive at Danish consumer prices. However, while Ea Energy Analyses has chosen to use the Sustainable Development scenario as a prediction for long-term fuel prices, the DEA has chosen the New Policies scenario as their central scenario in their outlook analyses.

3 IEA and World Bank fuel price comparisons

The following chapter compares the IEA and World Bank fuel prices, although in some respects, they are not directly comparable. For some fuels the prices represent different geographic regions, with the World Bank having fewer regional prices for coal and natural gas. On the other hand, the World Bank has annual price forecast figures up to 2021, along with the years 2025 and 2030. The IEA's first forecast figures are for 2025, and they continue for 5-year intervals until 2040. In the figures and analysis below, the comparison assumes linear development between datapoints, including the historical prices in 2016.

3.1 Oil

Figure 1-6 below displays the WEO crude oil price forecasts for IEA crude in the New Policies and Sustainable Development scenarios, and the World Bank's crude oil price forecast (all prices in 2016 USD).

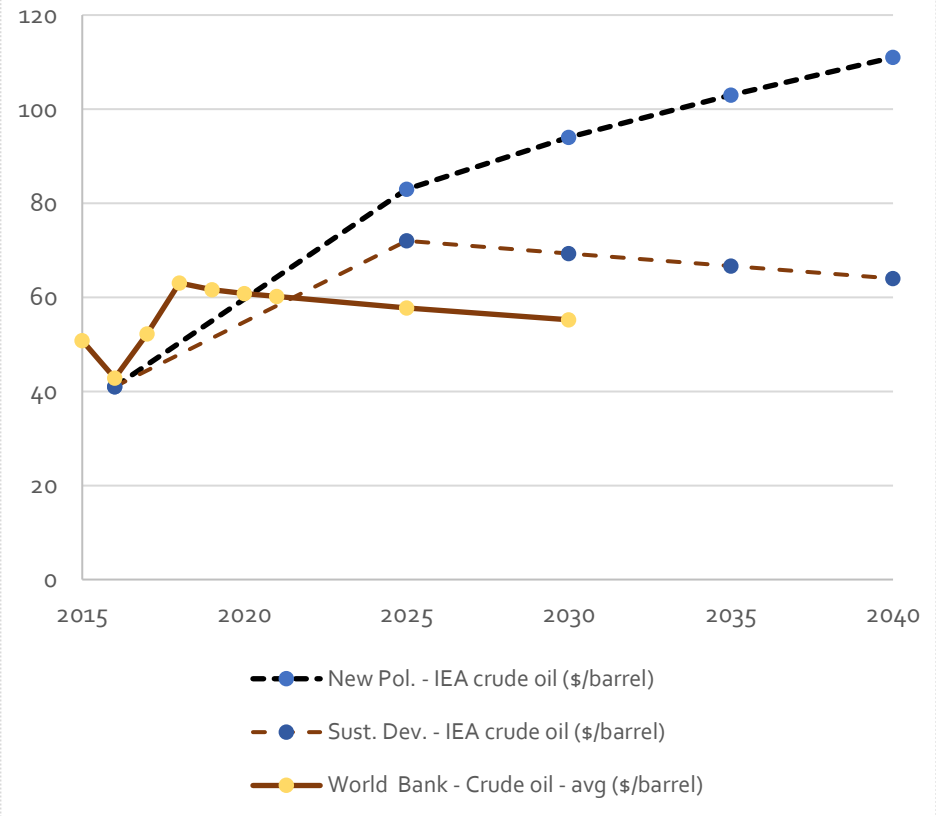

Figure 1-6: WEO crude oil price forecasts for IEA crude in the New Policies and Sustainable Development scenarios, and the World Bank's crude oil price forecast. All prices are in 2016 USD. Dots represent years with data points.

The IEA crude oil is a weighted average import price amongst IEA member countries, while the World Bank oil price is an average of Brent, Dubai Fetch, and WTI prices. As such, it is important to note that the two are not 100% directly comparable but given the global nature of oil as a traded product, they are likely to be quite comparable. The World Bank oil price forecasts are somewhat similar to the IEA's Sustainable development forecasts, as they both indicate a price increase, followed by slowly declining oil prices. The World Bank forecast foresees this occurring earlier, and with a lower peak price. The IEA's New Policies Scenario on the other hand anticipates that oil prices will continue to increase from 2015 levels to over $110 per barrel in 2040.

3.2 Coal

When reviewing the IEA and World Bank forecasted prices for coal (Figure 1-7 and Figure 1-8) the story is somewhat the same as was for oil, as the World Bank and IEA Sustainable price scenarios are somewhat similar after 2020, as they both anticipate a fall in prices.

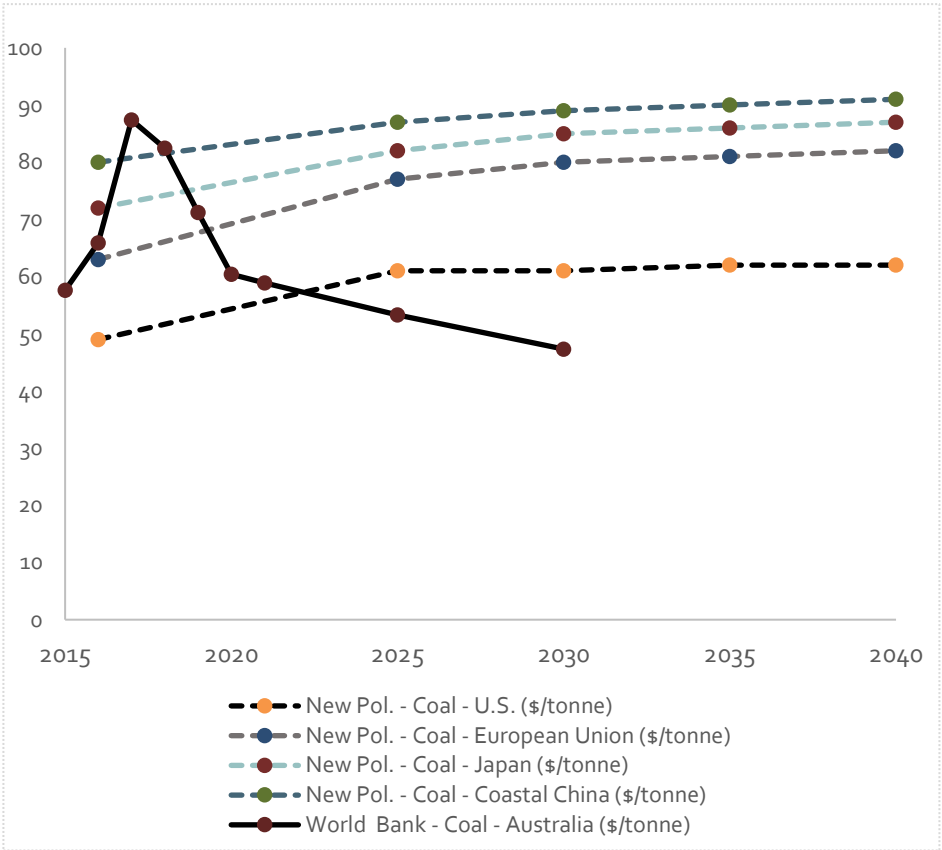

Figure 1-7: WEO coal price forecasts for various regions in the New Policies scenario, and the World Bank's Australian price forecast. All prices are in 2016 USD per tonne. Dots represent years with data points.

When comparing the World Bank and IEA oil and coal prices, it would appear that the World Bank forecasts are more focused on the short-term prices (there are data points from each year from 2015 to 2021, and in 2025 and 2030), whereas the IEA's first forecast data points are in 2025 and 2030, with IEA estimating also price forecasts for the years 2035 and 2040. A logical conclusion from this would be that the World Bank price forecasts would be more effective at capturing the short-term price developments. If we focus on the Australian coal prices, they averaged roughly 85-90 USD/tonne in 2017, and close to 100 USD/tonne thus far in August 2018, which is more closely reflected in the World Bank prices (Index Omundi, 2018). However, if the Australian coal prices maintain their current price level into 2019, then the IEA price forecasts from the region (Coastal China and Japan) will be closer to real prices (i.e. assuming a linear development from historical prices in 2016 to the first IEA forecast price in 2025).

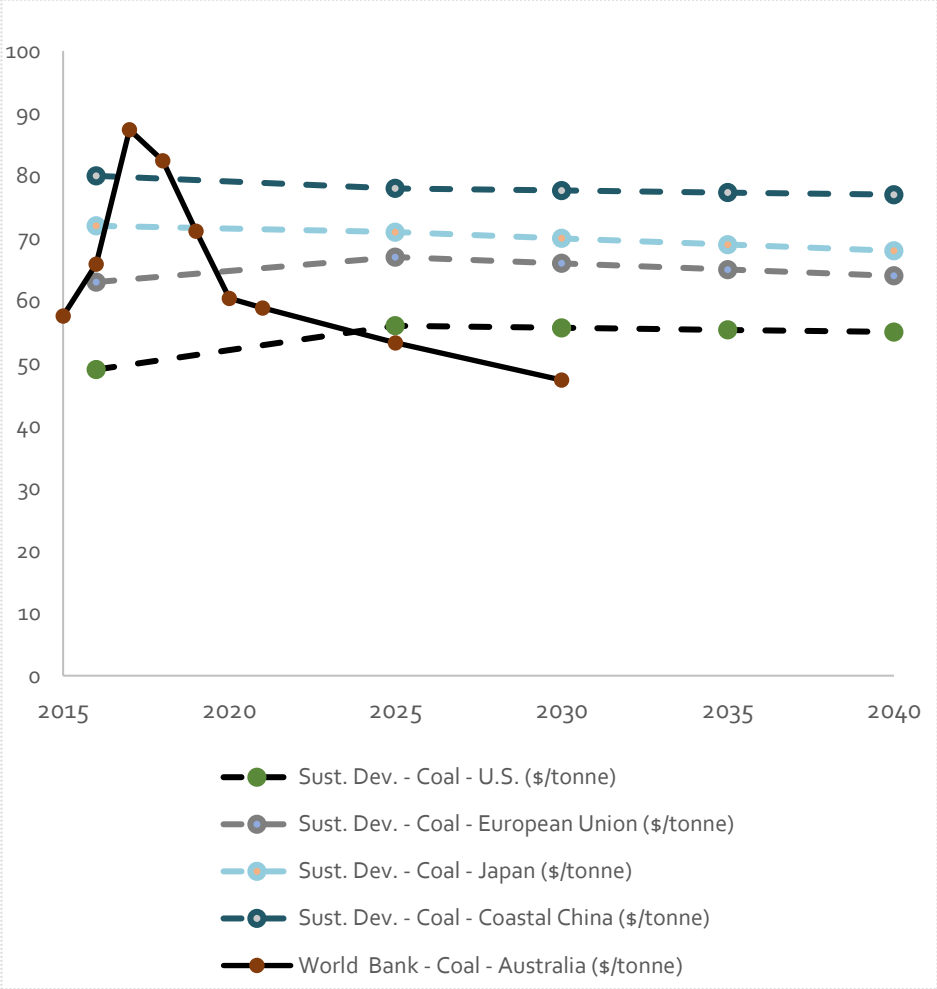

Figure 1-8: WEO coal price forecasts for various regions in the Sustainable Policies scenario, and the World Bank's Australian price forecast. All prices are in 2016 USD per tonne. Dots represent years with data points.

3.3 Natural gas

For natural gas, the World Bank and IEA price forecasts for the Sustainable Development Scenario are quite similar for 2020 and 2025 in all price regions (Figure 1-10), while the IEA natural gas price forecasts in the New Policies scenario are slightly higher for the United States, and considerably higher for the EU and Japan (Figure 1-9).

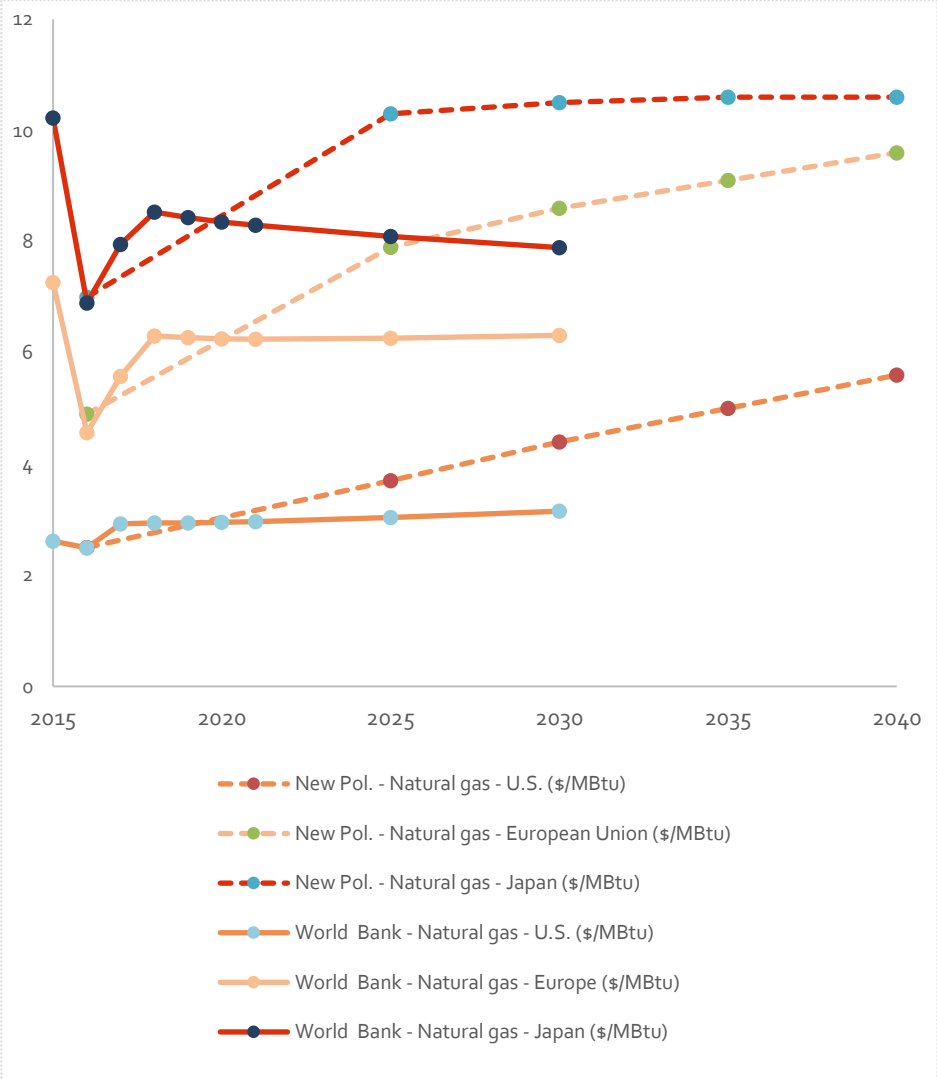

Figure 1-9: WEO natural gas price forecasts for various regions in the New Policies scenario, and the World Bank price forecasts for the same regions. All prices are in 2016 USD per MBtu. Dots represent years with data points.

In both Figure 1-9 and Figure 1-10 the natural gas prices are weighted averages expressed on a gross calorific-value basis. The US gas price reflects the wholesale price prevailing on the domestic market. The EU gas prices reflects a balance of pipeline and LNG imports, while the Japan gas price is solely LNG imports (LNG prices used are those at the customs border, prior to regasification).

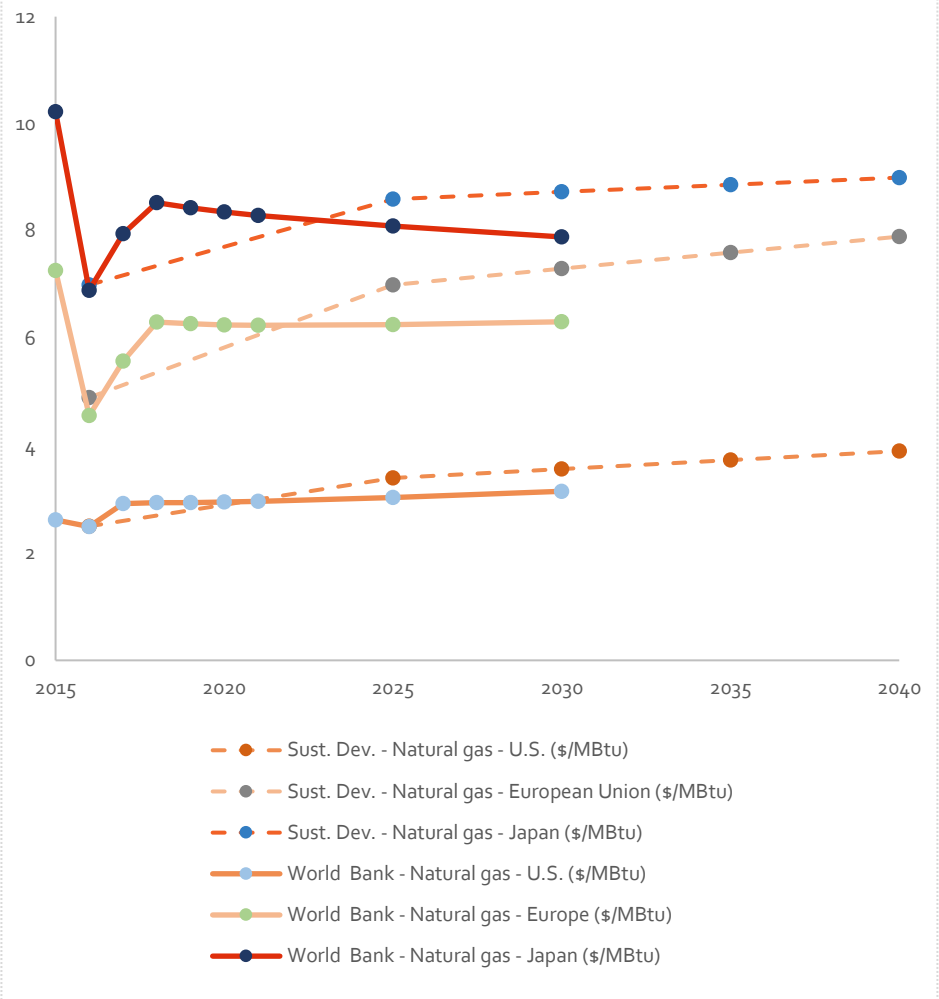

Figure 1-10: WEO natural gas price forecasts for various regions in the Sustainable Development scenario, and the World Bank price forecasts for the same regions. All prices are in 2016 USD per MBtu. Dots represent years with data points.

4 Comparison of historic IEA price forecasts

When reviewing price forecasts, it is relevant to investigate how the same price forecasts have developed over time, and how current prices at the time of the forecast impacted the price predictions. As the IEA World Energy Outlook has been published on a regular basis with a standard methodology for many years it is quite suitable for this form of review.

Numerous oil forecasts from WEO publications since 1994, along with the historical IEA crude oil price are displayed in Figure 1-11.

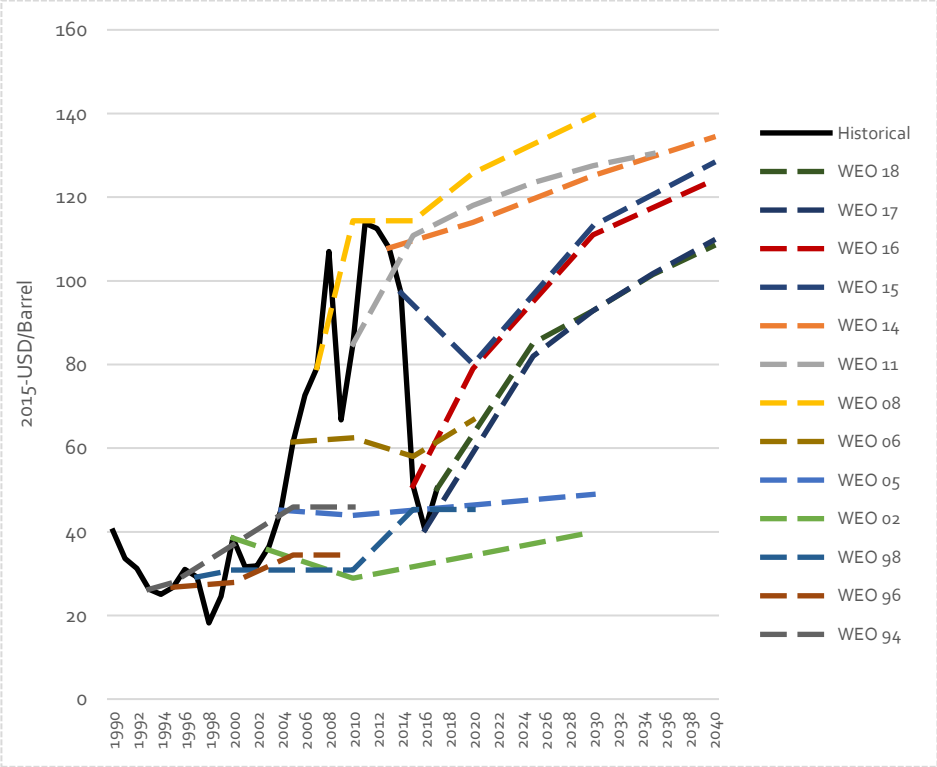

Figure 1-11: Prior IEA WEO price forecasts for IEA crude oil in what corresponds to the New Policies Scenario and actual historical prices (2015 USD per barrel). IEA crude oil is a weighted average import price amongst IEA member countries.

It is evident from the figure that the price level at the time of the publication is extremely relevant for the future price forecasts. Prior to 2004, when the average annual oil price had not been over $40 for more than a decade, none of the WEOs predicted a future oil price over $45. However, as oil prices started to increase rapidly from 2005 to mid-2008, the WEOs in these years also started to forecast much higher future prices. More recently, lower oil prices have once again seen lower forecasted future oil prices, as the 2017 WEO forecasted a 2040 price of $110 per barrel, considerably lower than the high

forecasted values for 2040 seen in the editions from 2016 ($124/barrel), 2015 ($128/barrel), and 2014 ($134/barrel).

In reviewing the same data for European natural gas (Figure 1-12 below), the story is nearly the same. Given that European oil and gas prices have historically been quite highly correlated, this is not surprising. If the same values were selected for US natural gas, the picture would be somewhat different, as the shale gas revolution in the US has led to a greater de-coupling of oil and natural gas prices in the US.

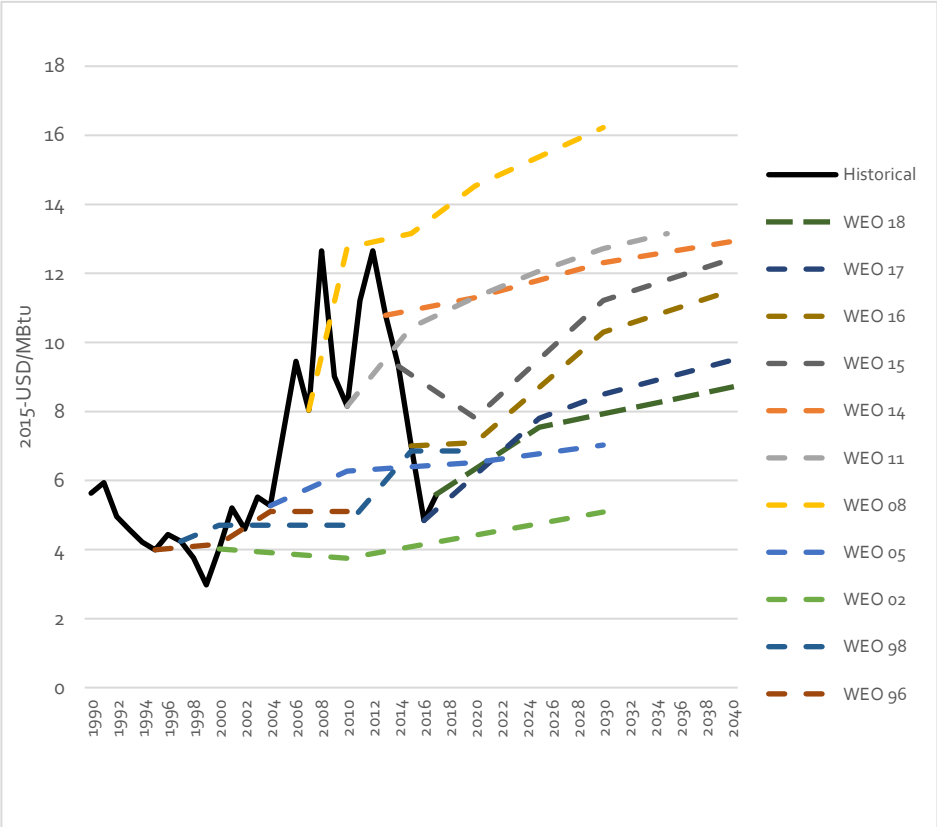

Figure 1-12: Prior IEA WEO price forecasts for the EU import price of natural gas in what corresponds to the New Policies Scenario and actual historical prices (2015 USD per MBtu).

Perhaps the clearest example of the current price having a direct effect on future prices is seen when reviewing the historic WEO forecasted prices for steam coal in Figure 1-13. While the future prices from various forecasts do converge slightly, many of the WEO forecasts are represented by somewhat straight, slightly rising lines, regardless of the current price level.

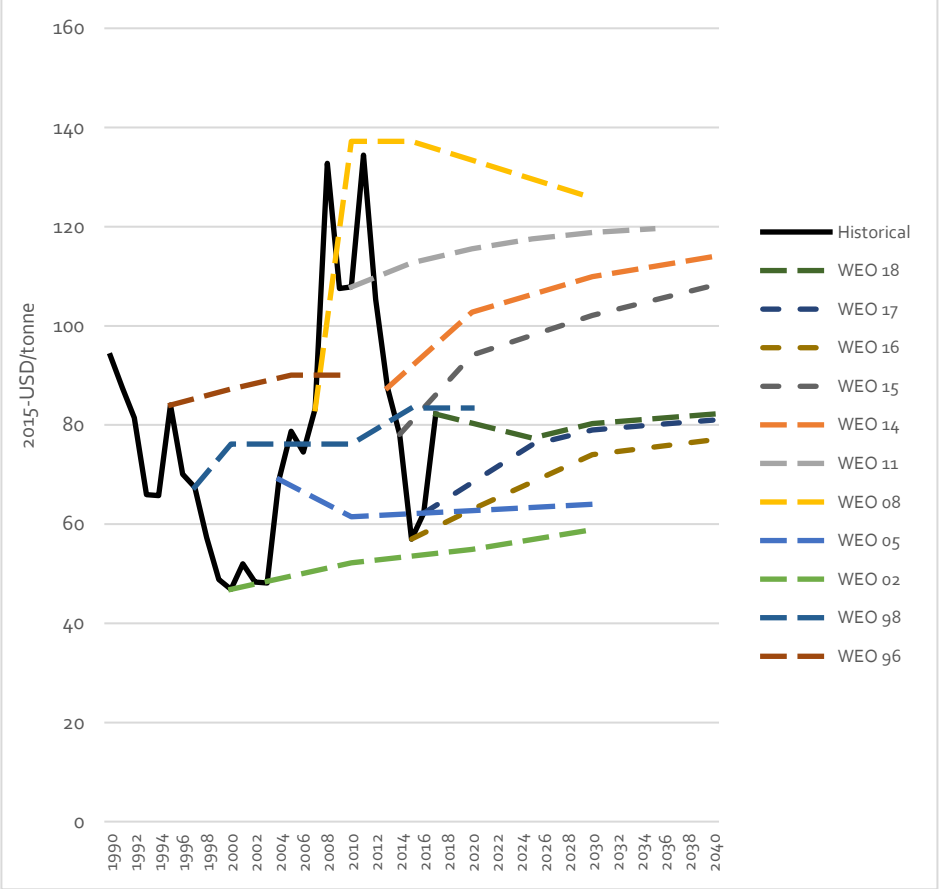

Figure 1-13: Prior IEA WEO price forecasts for coal in what corresponds to the New Policies Scenario and actual historical prices (2015 USD per tonne). For WEOs prior to 2016, the coal price is the OECD average steam coal import price. For WEO 2016 and 2017 the coal price is the EU average steam coal import price.

5 Prognoses for imported fuels

5.1 Conclusions on price comparison

Methodology availability

In evaluating which price forecasts to use in the future it is important to understand how these prices are derived, and what the most important drivers are. While complex, the IEA methodology for the World Energy Outlooks is well documented and constantly under refinement. On the contrary, the methodology for the World Bank prices is not publicly available, and it has not been possible to obtain more information in this regard.

Depth of analysis

The World Bank report encompasses over 40 commodities and only utilises a few pages to describe their 5 fuel price forecasts, whereas the WEO is an extensive publication numbering over 500 pages focused solely on energy related matters.

Additional scenarios

The fact that the WEO has three well-described primary scenarios is an advantage, as it both provides insight as to why future energy commodity prices are expected to develop, while also allowing the user of the data to determine which of the 3 scenarios are the most plausible going forward, and therefore which price data would be most appropriate to use.

Cost

The World Bank publication is free, whereas the IEA's WEO costs in the range of €120-600 depending on the number of users.

Time focus

The World Bank commodity forecast focuses more on the short-term price forecasts, whereas the WEO looks further into the future (WEO has 2035 and 2040 data points as well). While the methodology for short-term price estimation relies on forward/future prices (containing the most up-to-date market information and freely available reports), for the long-term projections, it is important to focus on a data source that can provide medium- to long-term forecasts, such as those provided by the WEO.

Quality assurance

It is disconcerting that the World Bank publication contains a significant error (see section 2.1) in its natural gas price forecasts and that this has not been corrected over half a year after the report publication.

5.2 Recommendations and suggested methodology

Based on the above aspects it is recommended to utilise the World Energy Outlook scenario prices as inputs for developing price forecasts for imported oil, coal and LNG in Vietnam, with the IEA New Policies Scenario (the IEA's

central scenario) being the main scenario. The following section outlines suggested methodologies for oil, coal and LNG that both incorporate near-term forward prices, and long-term WEO scenario price forecasts from the WEO 2018 (IEA, 2018, a).

Oil

Vietnam has recently inaugurated its 2nd oil refinery, and combined with projected growth in demand for oil-based products, and falling domestic crude production, it is anticipated that imports of crude oil will grow in the years to come. It is therefore relevant to develop a methodology for forecasting future oil import prices.

Forward prices for delivered crude

The majority of the initial oil deliveries to the new 200,000 barrels per day (bpd) Nghi Son refinery came from Kuwait, and it is assumed that the Middle East Gulf will likely be the primary exporter of oil to Vietnam going forward (Reuters, 2018). According to Platts, 'Platts Dubai' is one of the most widely used global oil price benchmarks, and it is the pricing reference for crude oil delivered to Asian refiners from the Persian Gulf (S&P Global Platts, 2018).

Long-term WEO prices for delivered crude

As noted previously, the IEA crude oil price published in the WEO is a weighted average import price amongst IEA member countries. Given that a large share of IEA member countries oil imports currently consist of oil imported by Asian countries from the Middle East, it is assumed that the Platts Dubai and IEA oil prices should be closely correlated. This appears to very much be the case when comparing the historic prices (see Figure 5-1).

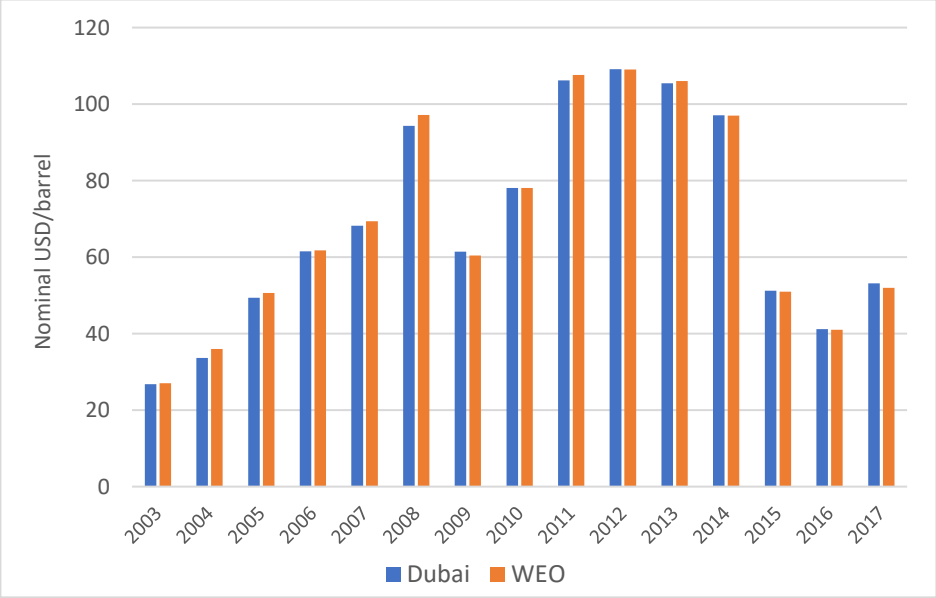

Figure 5-1: Historic prices for Platts Dubai crude (CME Group, 2018) , and IEA WEO crude oil.

Convergence profile

Utilising a publicly available forward price for Platts Dubai crude oil supplied by CME Group, and the long-term IEA price inputs, it is suggested to converge the two inputs together wherein forward prices weigh 100% during the first few years (until 2020), and gradually rely 100% on the IEA long-term price forecasts in 2030 (CME Group, 2018). Both of these price quotes represent delivered prices that are deemed to be representative of CIF Vietnam prices.

The suggested methodology results in price forecasts (black, blue and green solid lines) for the three IEA scenarios as displayed below in Figure 5-2.

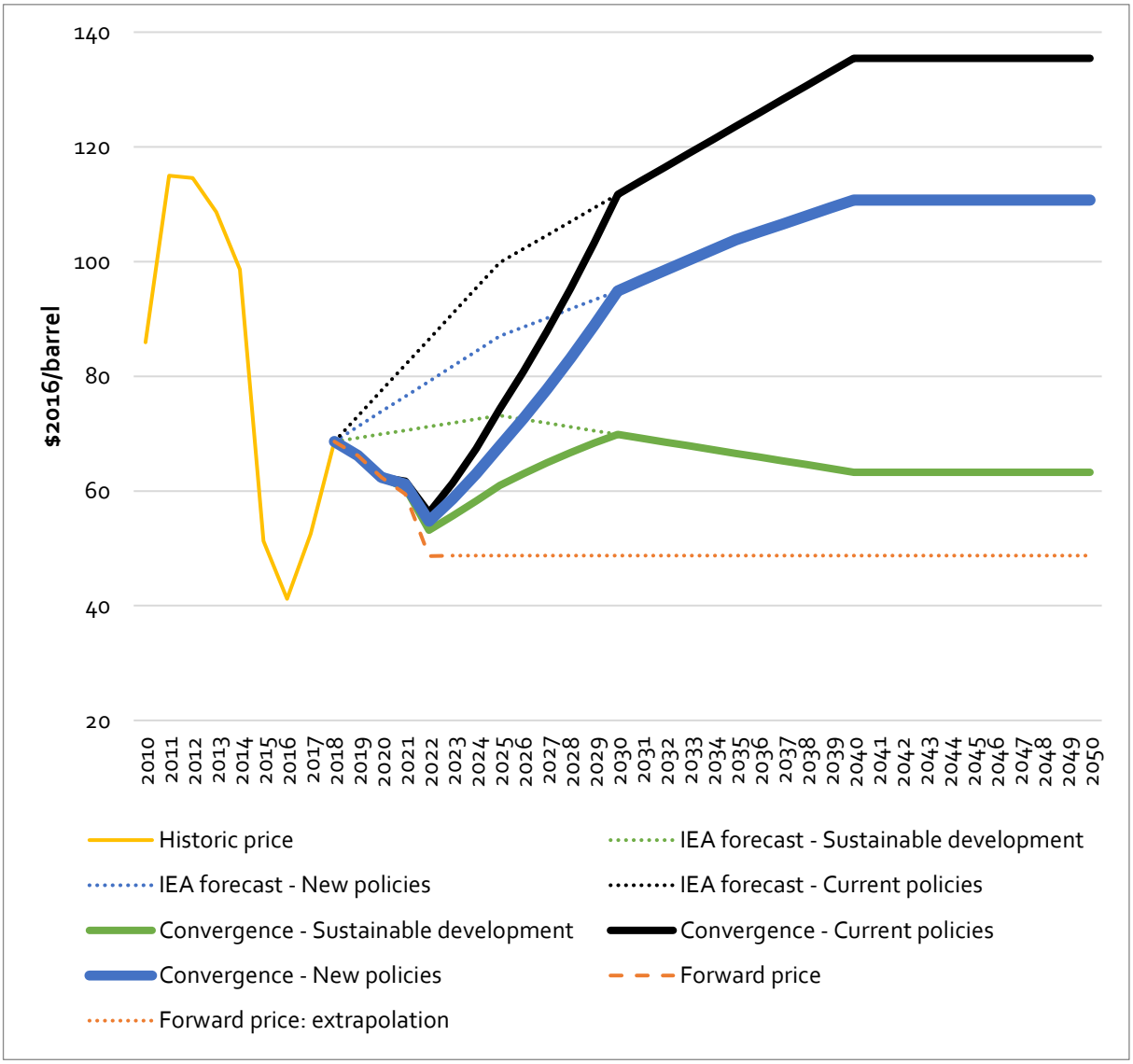

Figure 5-2: Imported oil price forecasts for Vietnam with the proposed methodology. All prices are CIF Vietnam. Note that the axis starts at 20.

Coal

Historically, Vietnam was an exporter of coal, but this changed in 2016 when Vietnam became a net importer. Net imports of coal have grown significantly since this time, as 2017 imports were estimated at roughly 12 million tonnes, a figure that is estimated to grow to 21 million in 2018, over 40 million by 2020, and potentially 100 million by 2030 (VOV, 2018). The majority of coal imports currently come from Indonesia, followed by Australia and Russia. Going forward the most relevant import markets are assessed to be Indonesia and Australia, and the historic coal prices from these two countries are displayed below.

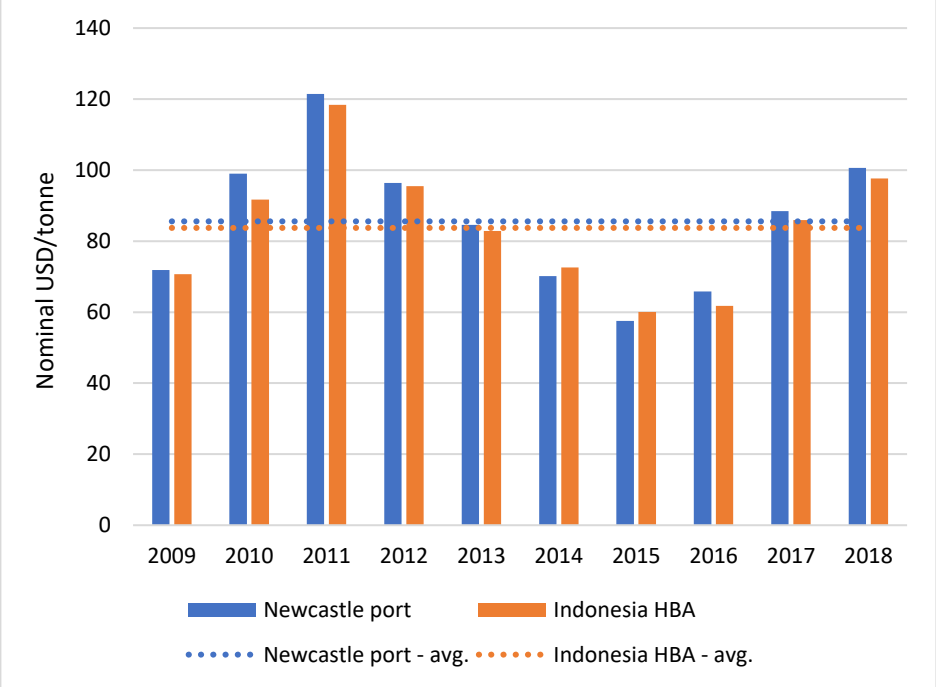

Figure 5-3: Historical coal prices in Indonesia (HBA) and the Australian port of Newcastle (FOB).

Figure 5-3 highlights how closely correlated the Indonesian and Newcastle prices have been historically, with the average difference between the two during the 10-year period being less than 2 USD/tonne. This is not surprising given that Indonesia's benchmark HBA price is set by Indonesia's Ministry of Energy and Mineral Resources based equally on 4 price elements (Platts, 2018):

- Platts Kalimantan (5,900 kcal/kg GAR assessment)
- Argus-Indonesia Coal Index 1 (6,500 kcal/kg GAR)
- Newcastle Export Index (6,322 kcal/kg GAR)
- globalCOAL Newcastle (6,000 kcal/kg NAR).

Forward prices: Indonesian coal

While there does not appear to be any free publicly available future/forward price estimates for Indonesian coal, there are a number of publicly available sources for forward prices for Newcastle coal, including the example displayed below from KPMG's quarterly Coal Price and FX Market forecasts (KPMG, 2018).

Year ended 31 December	Reporting date	2018	2019	2020	2021	2022	LT (2018)
Contributor 1	17-Jul-18	98.0	104.5	94.0	89.5	n/a	65.0
Contributor 3	12-Jul-18	97.0	85.0	75.0	75.0	75.0	75.0
Contributor 4	11-Jul-18	99.0	85.0	80.0	80.0	81.0	76.0
Contributor 5	10-Jul-18	101.0	85.0	82.0	78.0	73.0	67.0
Contributor 7	6-Jul-18	101.7	83.3	72.0	n/a	n/a	n/a
Contributor 8	4-Jul-18	91.0	75.0	75.0	n/a	n/a	n/a
Contributor 9	2-Jul-18	91.0	80.0	75.0	n/a	n/a	65.0
Contributor 10	1-Jul-18	96.6	84.5	78.6	76.3	70.0	n/a
Contributor 11	29-Jun-18	92.0	71.0	67.0	63.0	65.0	65.6
Contributor 12	27-Jun-18	107.0	85.0	65.0	63.0	63.0	58.0
Contributor 13	27-Jun-18	94.0	88.0	78.0	75.0	70.0	55.3
Contributor 14	26-Jun-18	102.0	89.0	86.0	n/a	n/a	77.0
Contributor 15	25-Jun-18	81.6	92.5	n/a	n/a	n/a	n/a
Contributor 16	21-Jun-18	87.0	81.0	75.0	75.0	71.0	65.0
Contributor 17	19-Jun-18	96.0	95.0	87.0	n/a	n/a	60.0
Contributor 19	7-Jun-18	99.0	79.0	74.0	76.0	77.0	n/a
Low		**81.6**	**71.0**	**65.0**	**63.0**	**63.0**	**55.3**
High		**107.0**	**104.5**	**94.0**	**89.5**	**81.0**	**77.0**
Average		**95.9**	**85.2**	**77.6**	**75.1**	**71.7**	**66.3**
Median		**96.8**	**85.0**	**75.0**	**75.5**	**71.0**	**65.0**
Previous bulletin (Mar/Apr18)							
Average		**90.2**	**81.2**	**76.5**	**72.8**	**71.4**	**65.3**
Median		**90.5**	**80.0**	**76.0**	**75.0**	**71.0**	**65.0**

Figure 5-4: Newcastle thermal coal (nominal USD/tonne).

As a result of the close correlation between the prices of Indonesian and Newcastle coal, it is suggested to use the forward price for Newcastle coal and adjust it with the historic average difference of just under 2 USD/tonne to arrive at forward price for Indonesian coal. If 2020 is taken as an example, then an estimate of a forward price for Indonesian coal could be 75 USD/tonne (median for 2019 from Figure 5-4) minus 2 USD/tonne, thus 73 USD/tonne.

WEO long-term price: Indonesian coal

The WEO has future price forecasts for Japanese coal, the majority of which comes from Australia (IEA, 2018b). Given an estimate of the shipping costs from Newcastle to Japan, it is therefore possible to determine an IEA-based

estimate for the future price of Australian coal. An estimate of this shipping cost can be derived from a Platts publication (see below), where it can be seen that the shipping cost was roughly 14 USD/tonne during 2017.

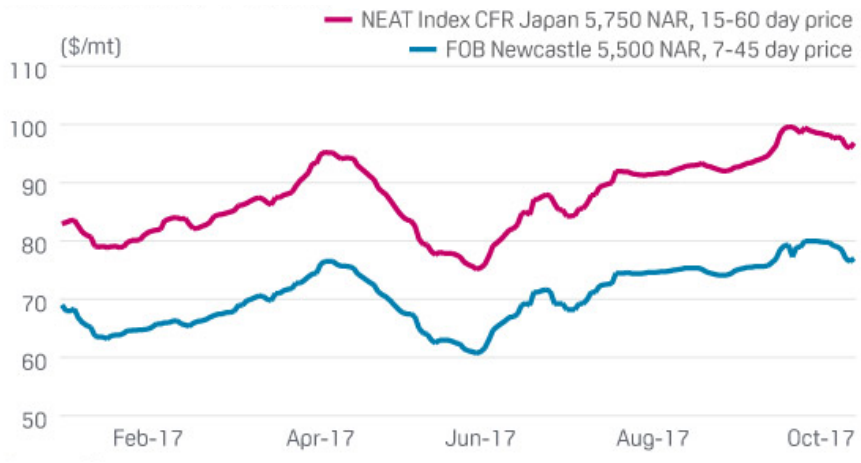

Figure 5-5: Thermal coal prices in Japan, and Newcastle, Australia during 2017 (Platts, 2017)

To arrive at an estimate for Indonesian coal in 2040 based on the New Policies scenario for example, then one would take the WEO price forecast for Japanese coal of 87 USD/tonne, and subtract 14 USD/tonne to arrive at a FOB Newcastle price of 74 USD/tonne. Assuming the same price difference between Indonesian coal and Newcastle coal of 2 USD/tonne, this yields a FOB Newcastle price of 72 USD/tonne.

Conversion of Indonesian coal prices to CIF Vietnam

The last step then involves converting Indonesian prices to CIF (Cost Insurance and Freight) Vietnam prices, or simply stated, the price of a commodity on a ship sitting in a Vietnamese harbour prior to offloading. Assuming shipping costs of roughly 14 USD/tonne between Australia and Vietnam, an initial very rough estimate of Indonesia to Vietnam shipping costs could be 6-10 USD/tonne.

Convergence profile

The aforementioned convergence profile (i.e. forward prices weigh 100% during the first few years, and gradually give weight to 100% reliance on the IEA long-term price forecasts) is then applied to the above forward and long-term IEA price inputs. In this respect it should be noted that the IEA price has been adjusted via the described add-on so that it reflects a Vietnamese CIF price. The suggested methodology results in price forecasts (black, blue and green solid lines) for the three IEA scenarios as displayed below in Figure 5-6.

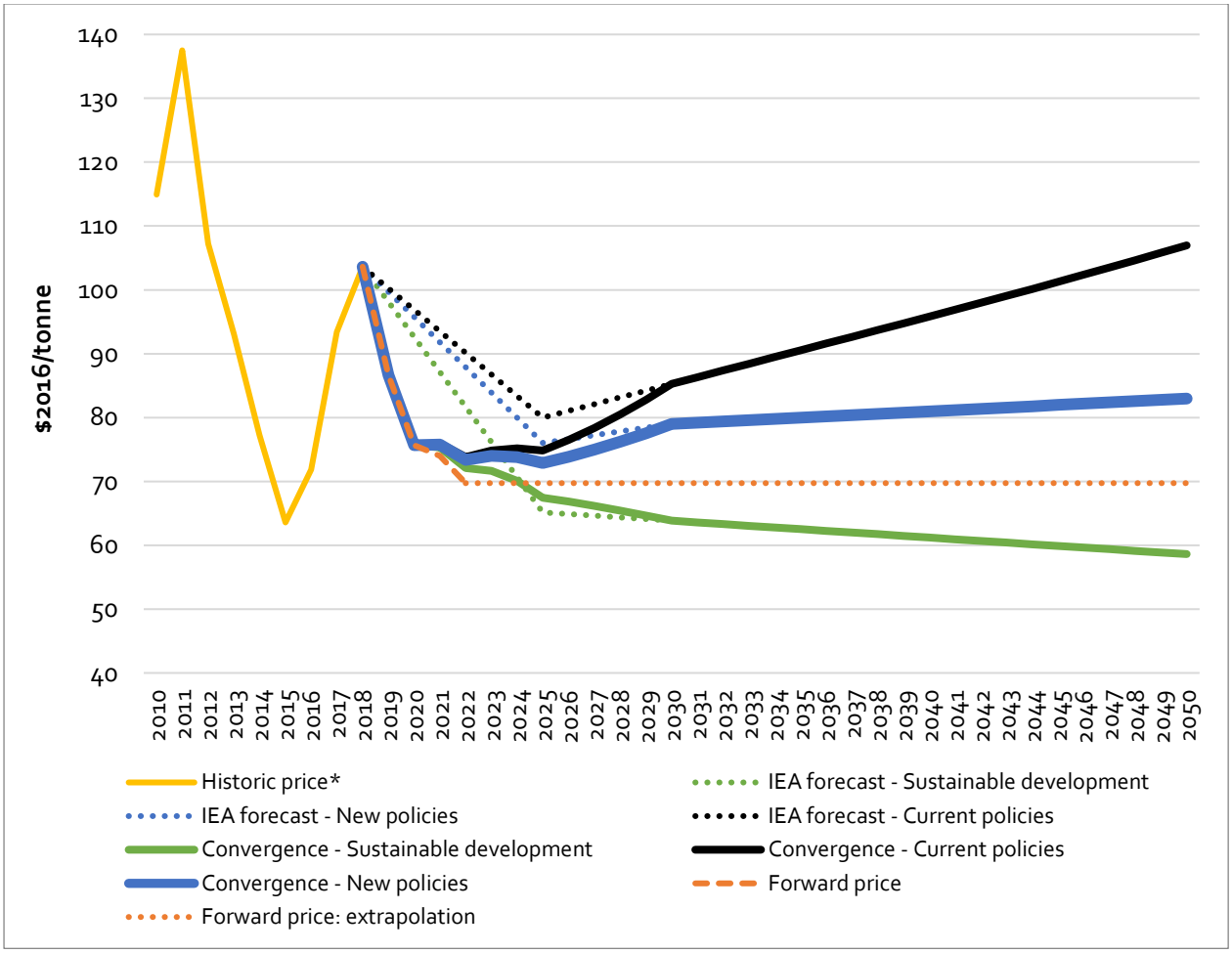

*Figure 5-6: Imported coal price forecasts for Vietnam with the proposed methodology. All prices are CIF Vietnam. Note that the axis starts at 40. *Historical cost is an estimate based on historic Newcastle prices converted to CIF Vietnam estimates.*

As can be seen from the figure, all 3 price forecasts rely solely on the forward price in 2018, 2019, and 2020. Thereafter, a growing weight is placed on the IEA based long-term price forecast, which is fully converged to in 2030.

There are a number of elements that can be fine-tuned in such a methodology, including:

- Until which year forward prices are used (currently 2020)
- The desired full convergence year (currently 2030)
- How to extrapolate the forward/future value in the years in which there are no forward/future prices. Currently this occurs from 2023 where the value from 2022 has been held constant towards 2050 (but has no effect after 2029 as there is full convergence in 2030)
- How to extend the IEA price forecasts from 2040 to 2050 as the last IEA data point is in 2040. Currently, for coal the same average growth rate that applies from 2035 to 2040 is applied through to 2050.

Imported LNG

The methodology for imported LNG is somewhat simpler. There are both IEA long-term forecasts for LNG delivered to Japan, and some publicly available prices for Japanese LNG futures contracts (however, these cover only the period up to 2020). A large portion of Japan's LNG imports currently come from Australia, and this is anticipated to only increase in the future. Given Australia's LNG export goals, it is also likely that a significant portion of Vietnam's LNG imports in the future could come from Australia. As the shipping distances from Australia to Japan are very similar to those from Australia to Vietnam, it is assumed that Japanese LNG import prices can serve as a good proxy for Vietnamese import prices. Applying this methodology results in gas price scenarios as depicted below.

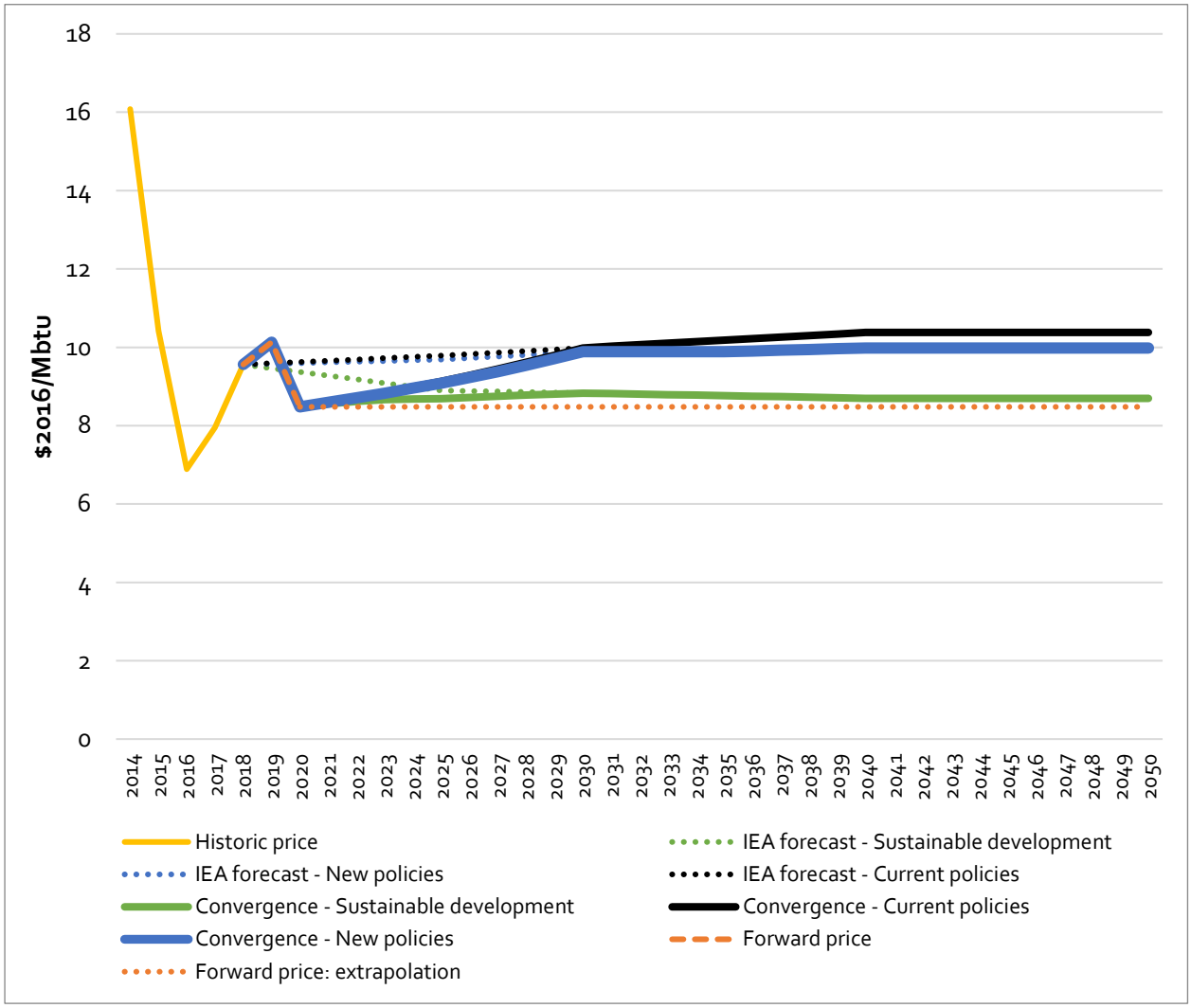

Figure 5-7: Imported LNG price forecasts for Vietnam with the proposed methodology. All prices are CIF Vietnam

5.3 Fuel prices at place of consumption

From CIF to consumption

The above price forecasts are all CIF Vietnam prices, i.e. the price of a fuel while still on a ship in a Vietnamese harbour. In order to arrive at prices at the place of consumption, sometimes referred to as gate prices, various adjustments to the CIF price must be made. Elements in these 'add-ons' include (but are not limited to):

- Harbour fees
- Offloading costs
- Storage costs in the harbour
- Costs related to loading, transportation, and offloading at the final destination.

For LNG, costly terminals are required in order to receive the LNG and convert it to natural gas. Therefore, this cost, along with the costs associated with usage of a pipeline to transport the natural gas, must also be added to the CIF price in order to arrive at a 'at power plant' natural gas price.

Many of these elements can be site/ship/fuel specific in nature. For example, unloading of a large coal ship may be cheaper on a per tonne basis because larger cranes can be utilised. Distances from a power plant to a harbour can also vary greatly.

Due to the site-specific nature of these cost elements, these will be addressed below in Chapter 7.

6 Historical Vietnamese fuel prices

Institute of Energy has provided historic fossil fuel prices in Vietnam that can be compared with international prices. Vietnamese domestic fuel prices have been regulated by the Government of Vietnam for a long time. Via Law No. 11/2012/QH13, the following products are subject to price stabilisation:

- Petroleum products;
- Electricity;
- Liquefied petroleum gas (LPG).

The regulation means that the prices for energy products should be stabilized under two circumstances: (i) the prices fluctuate abnormally and (ii) the prices have negative impacts on socio-economic stability. Moreover, in the energy sector, the Government also sets tariffs for electricity transmission and auxiliary services. Tariff schemes for electricity generation, bulk-supply and retail are under the Government's control as well.

Oil-based products

When comparing historic Vietnamese prices for oil-based products with the IEA crude oil price in Figure 6-1, it is clear that the prices are highly correlated (i.e. same development over time), which is to be expected for a globally traded product such as oil. Moreover, the refined products have a higher price than the raw crude oil, as expected.

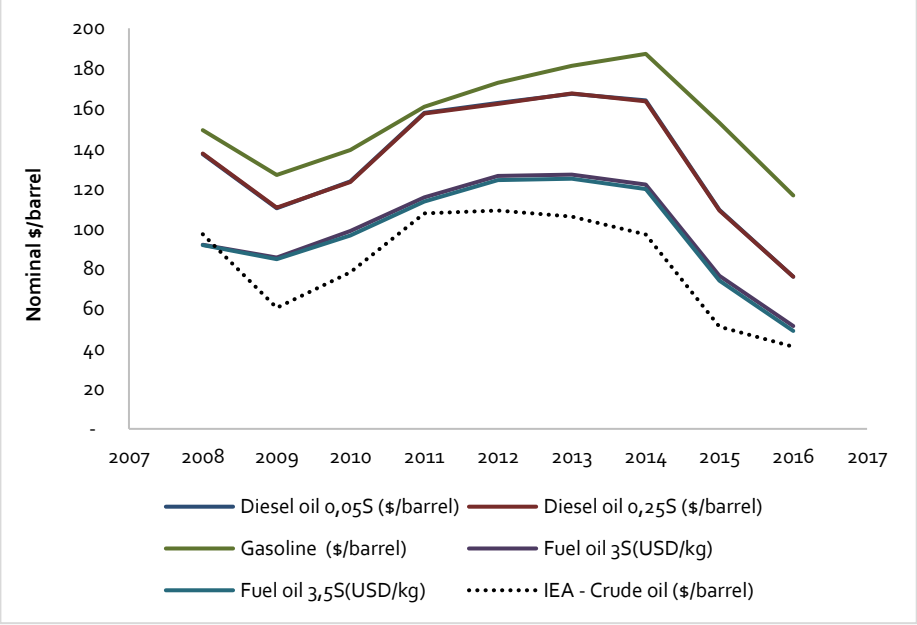

Figure 6-1: Historical Vietnamese prices for oil-based products compared to the IEA crude oil price. All prices are converted to nominal USD/barrel.

For petroleum products, the government sets “base prices” as price ceilings. The formula to calculate price ceilings includes various taxes and fees, including: import duties, special consumption taxes on gasoline and E5, a stabilization fund fee, an environmental protection tax and VAT. These taxes and fees are where the Government can exercise discretion to adjust petroleum product selling prices. The government has historically influenced end-user prices by adjusting import duties and making use of a price stabilization fund.

Natural gas

Natural gas pricing in Vietnam is based on two pricing mechanisms:

- Bilateral negotiation: Prices are negotiated between project proponents and PVN in upstream, and between PVN and end user in downstream; and
- Formula-based pricing: Government decides a formula for the price of gas supplied to fertilizer manufacturers and state-owned electricity generation companies. The prices are benchmarked/indexed to fuel oil price in Singapore.

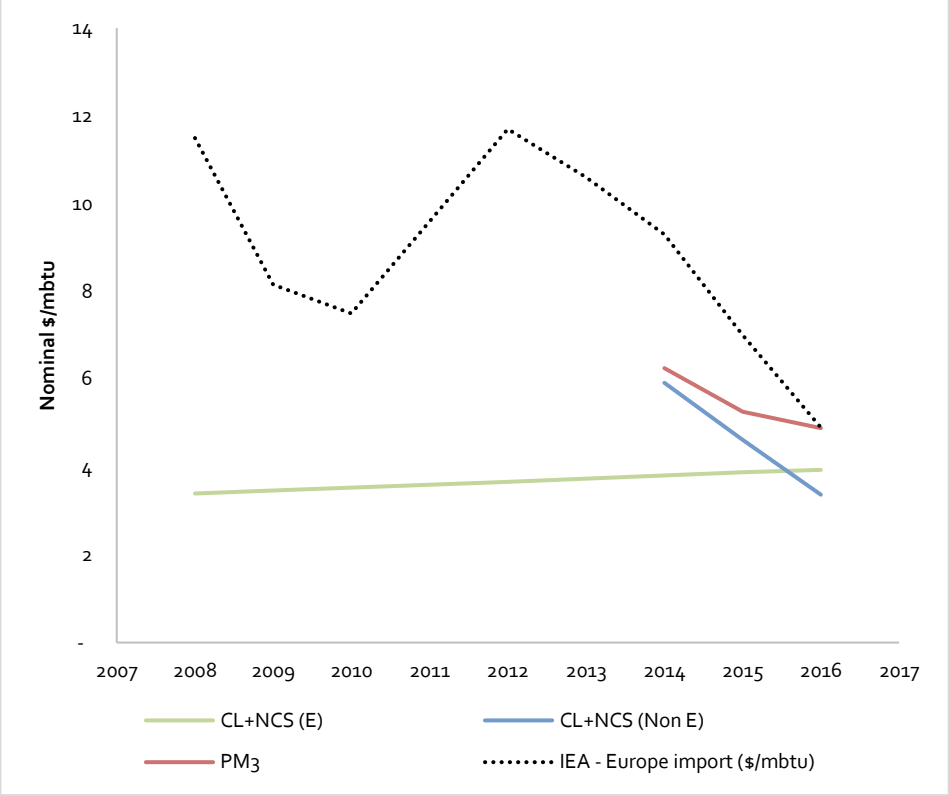

Figure 6-2: Natural gas prices. See Table 2 for fuel codes.

Fuel name	Specifications
CL+NCS (Exclusive)	Natural gas from South-East fields under exclusive amount, escalated price
CL+NCS (Non exclusive)	Natural gas from South-East fields above exclusive amount, indexed to fuel oil price in Singapore
PM3	Natural gas from South-West fields, indexed to fuel oil price in Singapore, including well price, transmission and distribution
Coal 4b	Calorific value (kcal/kg): 5300
Coal 5	Calorific value (kcal/kg): 4800
Coal 6a	Calorific value (kcal/kg): 4350
Coal 6b	Calorific value (kcal/kg): 4000

Table 2: Specification of Vietnamese fuel codes.

Coal

Vietnamese coal prices have also been regulated by the Government, and historically domestic coal prices were kept artificially low. Revenues from coal export were used to compensate for the domestic coal subsidises.

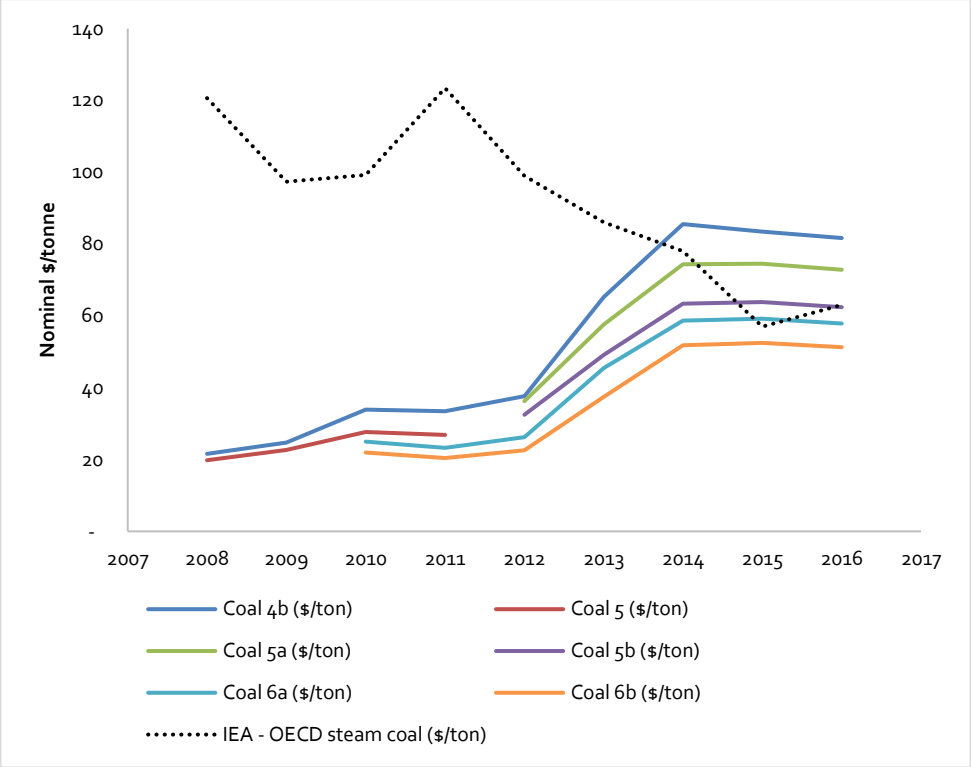

Figure 6-3: Historical Vietnamese prices for various coal qualities compared to the IEA OECD steam coal price. All prices are converted to nominal USD/tonne.

The current coal price scheme is comprised of the following:

- Coal prices are subjected to natural resource, environmental protection and export taxes;
- The frequency for adjusting coal prices is still low, with a late response to world coal price for keeping stable prices for domestic users;

- Government regulates export tax and/or export quota to limit coal export for meeting domestic demands sufficiently.

The result of these regulations is that the *regulated Vietnamese coal prices* have historically been far below the *international market prices*. Starting in 2012 however, Vietnamese coal prices have begun to converge to the international prices. By 2015, international steam coal prices were below the Vietnamese prices, but it is interesting to note that when international coal prices fell drastically (particularly in 2015 and 2016) prices were so low that a number of large coal producers filed for bankruptcy, with a prominent example being Peabody in the US. Commentators have since indicated that global prices in a number of regions were below the marginal production cost for some producers (IEA, 2017, a), and these bankruptcies would support these assertions.

7 Prognoses for domestic fuels

7.1 Domestic fuel price components

Domestic coal

Domestic coal types include anthracite, peat and fate coal with differences in size, heating value and other characteristics. Anthracite coal types are grouped into several subgroups, such as lump and dust coal, based on sizes of coal. Domestic coal types are shown below (Table 3).

No.	Coal type	Size (mm)	LHV (kcal/kg)	Production in 2016 (thousand tons)	Code in Balmorel	LHV in Balmorel (kcal/kg)
1	Anthracite lump	15-100	7100-7950	2,124		
2	Anthracite dust	<15		38,685		
	Dust coal 1-3	<15	6750-7800	2,377		
	Dust coal 4	<15	5300-6400	3,214		
	Dust coal 5	<15	4800-5600	10,746	Dom_coal_4b_5	5050
	Dust coal 6	<15	3700-4350	21,804	Dom_coal_6	4175
	Dust coal 7	<15	3150-3900	544	Dom_coal_7	3500
3	Peat	<0.5	3100-5550	489		
4	Fat coal			144		
				41,442		

Table 3: Domestic coal types (VIMCC, 2016).

The domestic coal used in the Vietnam-TIMES model is one typical anthracite coal with heating value of 5000 kcal/kg (21 GJ/ton), while the imported coal with heating value of 5500 kcal/kg.

Domestic coal prices are subjected to mining license fee, natural resource, environmental protection and other levies. Coal taxes in 2016 are summarized below:

No.	Components	Level	Amount	
			VND/ton	USD/ton
1	Natural resource tax (%)	8%	109,063	5.02
2	Mining license (%)	2%	28,738	1.32
3	Environmental fee (VND/ton raw coal)	10.000	11,600	0.53
4	Environmental protection tax (VND/ton)[5]		20,000	0.92
5	Other levies (%)	0,50%	8,000	0.37
	Total		**177,401**	**8.17**
6	**Financial cost**			**5.50**
7	**Return**			**4.90**
8	**Domestic shipping**			**5.00**

Table 4: Domestic coal add-ons. Source: (VIMCC, 2016).

Components of domestic coal price in 2016 (as real value 2016) are as below:

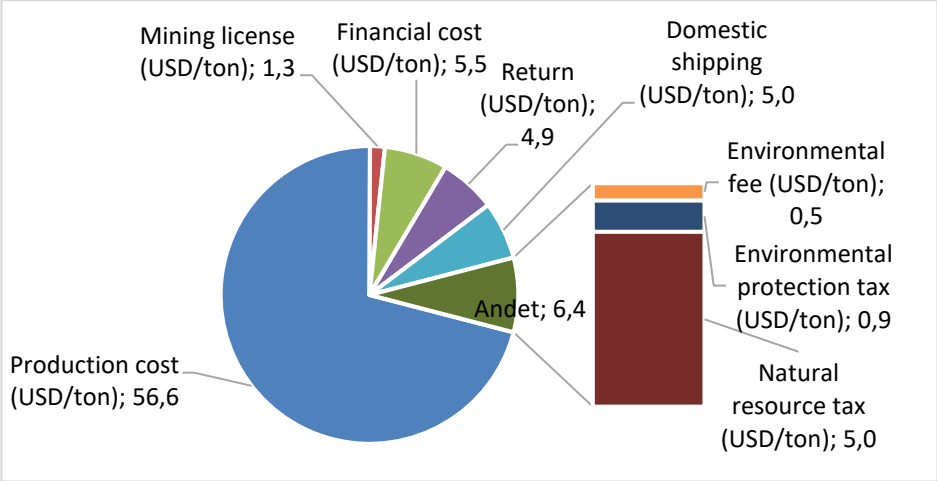

Figure 7-1: Coal price components in 2016. Source: adapted from (VIMCC, 2016).

Calculated domestic coal price is estimated as 79.6 USD/ton covering all price components. The cost was projected based on total cost and total coal production by Vinacomin in future years. Domestic coal cost without taxes is estimated at 73.2 USD/ton which accounted for 92% of the final price. Main assumptions for the production cost and the add-ons are as below:

- Production cost for domestic coal is projected to increase in the Coal Development Plan Revised (VIMCC, 2016) due to increasing amount of coal from underground mines in future years. Production cost will rise

[5] Environmental tax protection for anthracite coal will be 30,000 VND/ton from 1st January 2019

from 56.6 USD/ton by 2016 to 72.4 USD/ton by 2030 and to 78.3 USD/ton by 2050 (2% escalation rate in 2030-2050);

- Domestic shipping cost is projected to decrease from 5 USD/ton by 2016 to 3 USD/ton by 2050 due to improved road and waterway freight transport;
- Mining license fee is projected to remain constant at 1.3 USD/ton in 2016-2050;

Domestic natural gas

Domestic natural gas is being extracted mainly in the South of the country, from oil-prone basin and gas-prone basins in the South East and from offshore area jointly with Malaysia the South West. In the North, gas extraction from small deposits has commenced in 2015. Natural gas distribution geographically is further detailed as below (Table 5):

Region	Basin	Features
South East	Cuu Long	Oil prone basin in operation since 1995, delivered > 5.66 Bcm (44%) of nation-wide gas production. Production in decline.
	Nam Con Son	Gas prone basin in operation since 2003, delivered > 61.33 Bcm (48%) of nation-wide gas production. NCS2 in operation since 2016. Production in decline.
South West	Malay-Tho Chu	Offshore area administered jointly with Malaysia. Ca Mau pipeline in operation since 2007. Ca Mau supplied from Block PM3-CAA + Cai Nuoc field Delivered > 10 Bcm (8%) of nationwide gas production. Not yet reached maximum production capacity
North	Song Hong	Gas extraction from small deposits has recently commenced. Production expected to increase.
Central		Production expected to be started by 2023 with Ca Voi Xanh fields

Table 5: Domestic natural gas by region. Source: (IES; EMC, 2017).

Domestic gas prices include wellhead price, pipeline and distribution costs. Wellhead prices can be set based on bilateral negotiations, Government pricing regulation or indexation to fuel oil price[6]. Pipeline and distribution costs vary much by natural gas field.

[6] Singapore 180 CST high sulfur fuel oil as in Platt (HSFO 180)

Natural gas price from Nam Con Son – Cuu Long field from October 2015 was regulated as 100% of formula-based value, which is indexed to fuel oil price[7]. This price for April 2016 was calculated at 3.0831 USD/MMBTU, which was based on the following components:

- Wellhead price: 46% price of HSFO 180 = 0.46 x 153.84 (USD/ton) x 42.84 (GJ/ton) x 0.9478 (GJ/MMBTU) = 1.7429 USD/MMBTU;
- Pipeline cost: 1.19021 USD/MMBTU with escalation rate of 2% per year;
- Distribution cost: 0.15 USD/MMBTU with assumption of remaining constant over time.

There are several ways for indexing wellhead price with fuel oil price. Natural gas price forecasts are influenced by the historical very low prices with objective to minimize input costs for power generation and fertilizer production (IES; EMC, 2017). Wellhead prices for future gas deposits are expected to be much higher than the existing ones.

7.2 Domestic add-ons for imported fuels

Imported oil products

Vietnam has two existing refineries with Binh Son Refinery started operating in 2009 and Nghi Son Refinery in 2018. Total oil refinery capacity currently is of 16.5 Mt of crude oil. The former refinery consumes local crude oil while the latter refines imported crude oil. Vietnam is still importing all oil products to meet the country's demand. In 2016, Vietnam imported 12.7 Mt oil products as below (Table 6):

Product	Amount (tons)	Average import price (USD/ton)	Average import price (VND/l)	Average consumer price (VND/l)	Add-on value (VND/l)
Diesel oil	6,714,319	416.0	8,066	11,521	3,455
Kerosene	49,866	443.5	8,000	10,219	2,219
Jet fuel	1,924,927	452.6	8,163	11,735	3,571
Gasoline	2,487,606	528.2	8,710	16,386	7,676
Fuel oil	882,821	245.9	5,477	8,956	3,479

Table 6: Import of oil products in 2016. Source: Custom Office data on oil products import-export

[7] Official letter of Government Office No. 2175/VPCP-KTTH on market-based natural gas price

Domestic oil product price consists of several components such as import duties, special consumption taxes, a stabilization fund fee, environmental protection tax, VAT, distribution cost norm, return. Details on these components currently are presented below:

Component	Gasoline	Gasoline E5	Diesel oil	Kerosene	Jet fuel	Fuel oil
Distribution cost norm (VND/l)	1050	1250	950	950	-	600
Profit margin (VND/l)	300		300	300		300
Import duty (%)	10.0		1.03	0.11	7.0	3.26
Special consumption tax (%)	10	8				
Environmental protection tax (VND/l)	3000		1500	300	3000	900
Stabilization fund fee (VND/l)	300		300	300		300
Value added tax (%)	10	10	10	10	10	10

Table 7: Domestic oil products' price components

Imported coal

Coal is being imported into Vietnam from four main sources: Indonesia, Australia, Russia and China (the four countries contribute to 92.3% of the total imported coal). Amount of coal import in 2016 reached 13.3 million tons, of which 3.98 Mt from Australia, 3.69 Mt from Russia, 2.95 Mt from Indonesia, 1.64 Mt from China and 1.02 Mt from 15 other countries. Coal import for power and cement was of 11.57 Mt (83%) with an average price of 61 USD/ton. Coal import for steel and fertilizer was of 1.7 Mt (13%) with an average price of 147 USD/ton[8].

Main domestic add-on for imported coal prices is cost of port handling, this cost is projected at 10 USD/ton by 2020 and reduced to 5 USD/ton by 2050

[8] Calculated from GSO's database for imported goods https://www.gso.gov.vn/xnkhh/

due to enhanced infrastructure for importing coal. The shipping cost domestically is also assumed at 5 USD/ton.

Imported LNG

Alternative terminals under evaluation/planning for imported LNG have been identified as below (Table 8):

No.	Region	Possible terminal	Expected year of operation	Capacity	Main users
1	South East	Thi Vai	2021	1-1.5 Mt	Nhon Trach 3&4 CCGGT
2	South West	Hon Khoai	2022	1-2 Mt	Kien Giang, O Mon, Ca Mau GDC
3	South East	Son My	2023	3-6 Mt	Son My, Phu My GDC

Table 8: Identified LNG terminals. Source: (PVE, 2016).

For imported LNG price, the add-ons by 2020 are estimated as below[9]:

- Overhead cost and return: 0.45 USD/MMBTU, about 5% of LNG CIF price;
- Receiving, storage and regasification (LNG Thị Vải): 1,367 USD/MBTU, no escalation.
- Distribution cost:
    - South East: Nhơn Trạch 3&4 with total of 0.87 USD/MMBTU (i) from LNG Thị Vải to GDC Phú Mỹ: 0.1 USD/MMBTU; (ii) GDC Phú Mỹ là 0.15USD/MBTU; pipeline Phú Mỹ - Nhơn Trạch: 0.62 USD/MMBTU with escalation rate of 2% per year;
    - South West: from LNG about 1.31 USD/MMBTU with escalation rate of 1% per year.

7.3 Domestic fuel price prognoses

This section provides an overview of the final fuel prices used as input in the models for long term energy scenarios of the DEPP. For the main scenarios the price for imported fuels is based on IEA's New Policies scenario from World Energy Outlook 2018. The prices used as input to the modelling do not contain taxes and subsidies because the purpose of the scenarios is to find the least socio-economic cost under the given constraints of each scenario.

[9] Petro Vietnam's Official Document No. 6886/DKVN-HĐTV

Oil price

Base prices for domestic oil products are adjusted for every 15-day based on world oil prices. Therefore, domestic oil prices are highly correlated with world crude oil prices. Domestic CIF oil prices are forecasted based on the growth rate of projected world crude oil price (see section 5.2).

Prices at place of consumption projected for oil products in CP and SD scenarios (with added distribution cost and return and without taxes) are presented below:

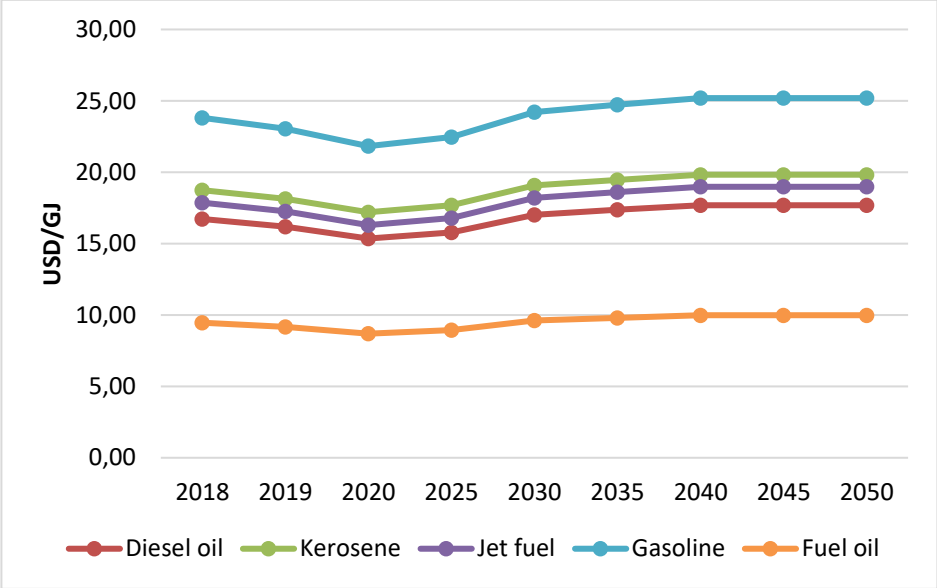

Figure 7-2: Domestic oil product prices in CP scenario.

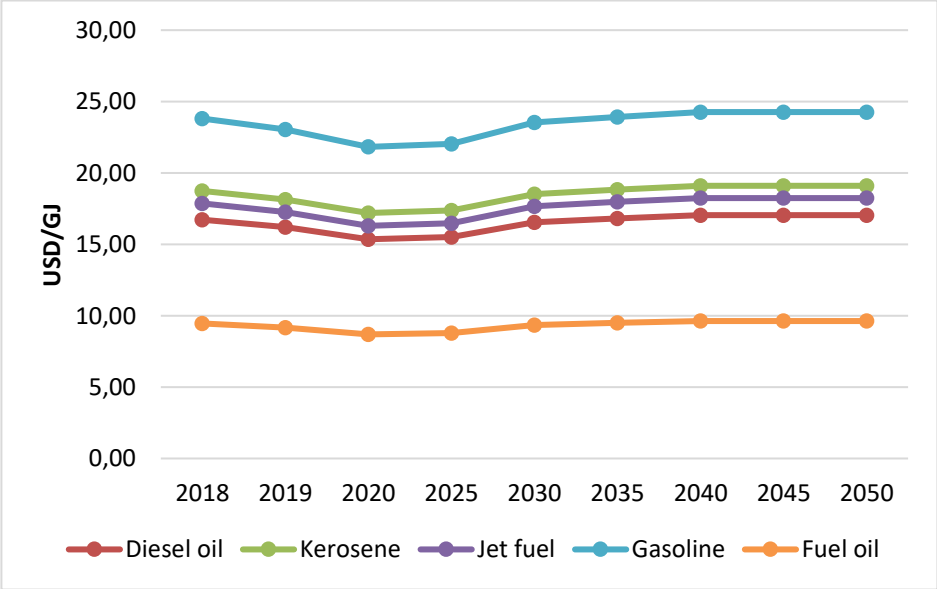

Figure 7-3: Domestic oil product prices in NP scenario

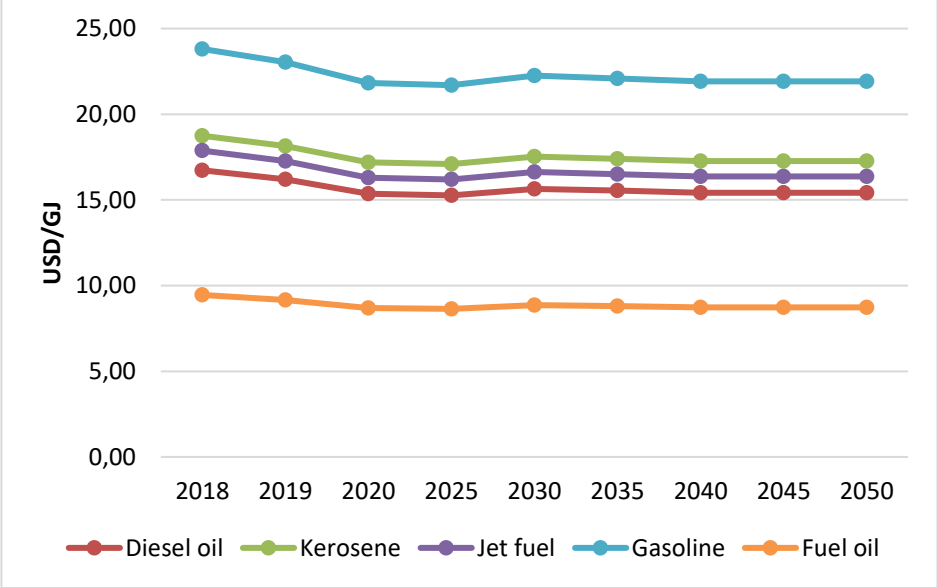

Figure 7-4: Domestic oil product prices in SD scenario.

	2018	2019	2020	2025	2030	2035	2040	2045	2050
Current policy scenario									
Diesel oil	16.73	16.20	15.35	15.79	17.02	17.37	17.69	17.69	17.69
Kerosene	18.74	18.15	17.20	17.69	19.07	19.46	19.82	19.82	19.82
Jet fuel	17.88	17.26	16.30	16.80	18.21	18.61	18.98	18.98	18.98
Gasoline	23.81	23.04	21.83	22.46	24.22	24.73	25.19	25.19	25.19
Fuel oil	9.45	9.16	8.69	8.93	9.61	9.81	9.98	9.98	9.98
Sustainable development scenario									
Diesel oil	16.73	16.20	15.35	15.26	15.65	15.54	15.42	15.42	15.42
Kerosene	18.74	18.15	17.20	17.09	17.53	17.40	17.27	17.27	17.27
Jet fuel	17.88	17.26	16.30	16.19	16.63	16.51	16.38	16.38	16.38
Gasoline	23.81	23.04	21.83	21.70	22.25	22.09	21.93	21.93	21.93
Fuel oil	9.45	9.16	8.69	8.64	8.85	8.79	8.73	8.73	8.73

Table 9: Summary on prognoses results for oil product prices.

Coal price

Coal prices in energy terms are forecasted for three different domestic coal types. Projections for domestic coal prices at place of consumption (i.e. including production cost, shipping and mining license fee, and excluding taxes) are presented below and compared with imported coal prices for three different scenarios (IEA, 2018, a)

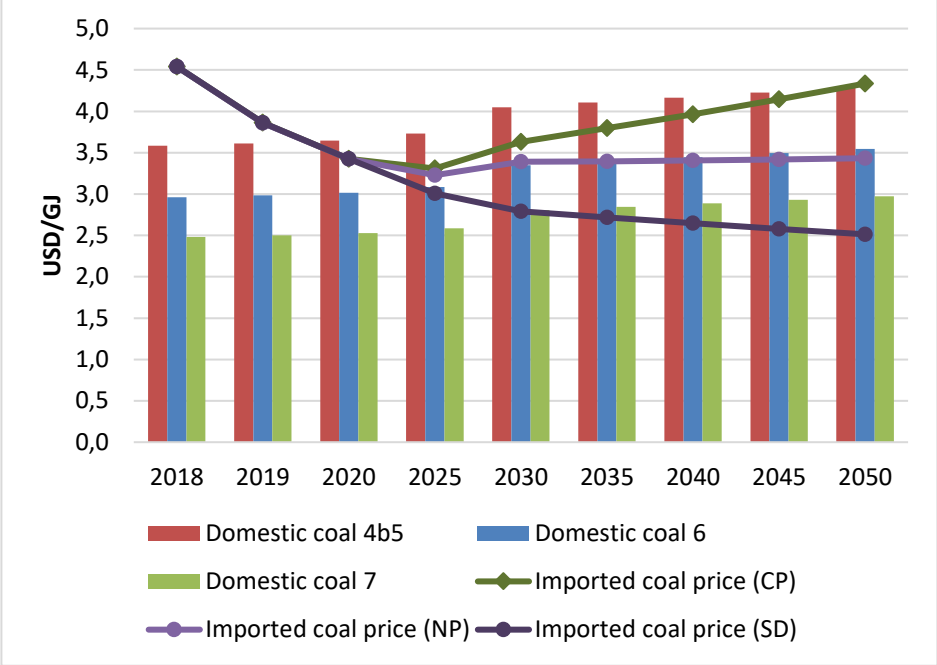

Figure 7-5: Comparisons of domestic coal and imported coal prices.

Domestic coal prices before 2020 are well below the imported prices. After 2020, the price of domestic coal 4b5 is even higher than imported coal price in the Current policies scenario. Prices of the other two coal types are in range between imported coal prices for the two IEA's scenarios. Due to the increased trend of domestic production cost, domestic coal production may be lower than planned in case of world coal price decrease due to climate change policies. Final domestic coal prices are projected as below:

	2018	2019	2020	2025	2030	2035	2040	2045	2050
Imported coal (SD)	4.5	3.9	3.4	3.0	2.8	2.7	2.6	2.6	2.5
Imported coal price (NP)	4.5	3.9	3.4	3.2	3.4	3.4	3.4	3.4	3.4
Imported coal (Current policies)	4.5	3.9	3.4	3.3	3.6	3.8	4.0	4.1	4.3
Domestic coal 4b5	3.6	3.6	3.6	3.7	4.0	4.1	4.2	4.2	4.3
Domestic coal 6	3.0	3.0	3.0	3.1	3.3	3.4	3.4	3.5	3.5
Domestic coal 7	2.5	2.5	2.5	2.6	2.8	2.8	2.9	2.9	3.0

Table 10: Summary of domestic coal price prognoses (USD/GJ). Source: authors' calculations.

Domestic coal 6 and 7 (two main coal types for power) can compete with imported coal in CP and NP scenarios. In the SD scenario with very low world coal price, domestic coal prices must be adjusted to lower values due to market mechanisms to compete with imported coal from abroad. Domestic coal prices might align with the international prices at certain point of time. This means that the domestic coal utilities would adjust production following the

price signals. To keep domestic coal price competitive, the coal utility would produce coal at the quantity where its supply cost intersects international coal price.

For the long term energy modelling purposes, the domestic coal prices will have a cap corresponding to the chosen IEA fuel price scenario. Example: If New Policy duel price scenario is selected, the maximum domestic coal price in 2050 will be 3.4 USD/GJ (as a consequneces the 2050 price of coal 4b5 and coal be 3.4 USD/GJ while coal 7 will have a price of 3.0 USD/GJ)

Gas price

Comparison of future trends for domestic gas prices and IEA´s imported LNG prices at the place of consumption are presented below:

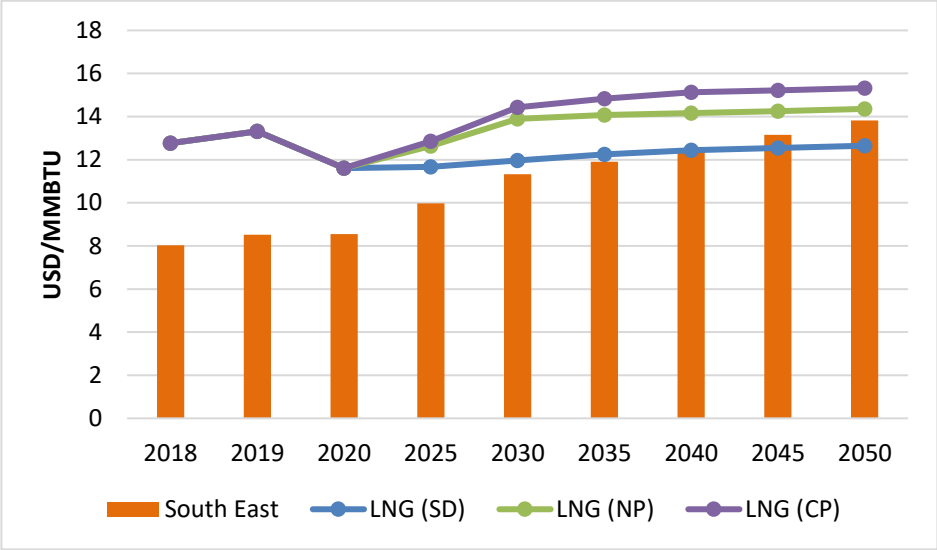

Figure 7-6: Comparisons of natural gas and LNG prices in South East region.

Price at the place of consumption of domestic natural gas in the South East region will be lower than imported LNG in all three scenarios. Only in SD scenario, imported LNG will be lower than domestic gas from 2040 onwards.

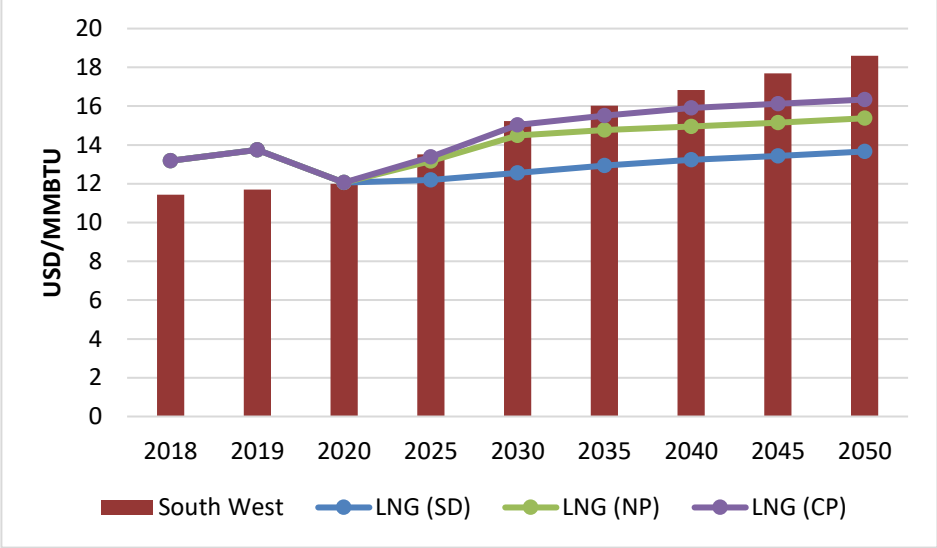

Figure 7-7: Comparisons of natural gas and LNG prices in South West region.

Due to high natural gas price from Block B, imported LNG can compete with domestic natural gas from 2020-2025 in all three scenarios. After 2025, the price of domestic gas in the South West must be adjusted to compete with imported LNG. The gas price in the region may be set by LNG price from 2025 onwards.

Detailed fuel price prognoses for natural gas and imported LNG are as below:

Year	Domestic natural gas			LNG South East			LNG South West		
	South East	South West	Central	SD	NP	CP	SD	NP	CP
2018	8.03	11.43	9.51	12.77	12.77	12.77	13.19	13.19	13.19
2019	8.52	11.7	9.74	13.31	13.31	13.31	13.75	13.75	13.75
2020	8.55	11.99	9.99	11.61	11.61	11.61	12.06	12.06	12.06
2025	9.98	13.52	11.3	11.67	12.64	12.85	12.20	13.16	13.38
2030	11.33	15.24	12.78	11.96	13.89	14.43	12.56	14.49	15.03
2035	11.91	16.02	13.43	12.25	14.07	14.82	12.94	14.77	15.52
2040	12.52	16.83	14.12	12.44	14.16	15.12	13.23	14.95	15.92
2045	13.15	17.69	14.84	12.54	14.25	15.22	13.44	15.15	16.12
2050	13.82	18.60	15.59	12.64	14.36	15.32	13.66	15.38	16.34

Table 11: Projection results for natural gas and imported LNG. Source: Authors' calculations.

Biomass prices

Biomass prices are collected from recent Biomass Development Plan (IE, 2016). Due to lack of data for different components in prices (i.e. transport, treatment etc.), biomass prices considered here are the final prices to end-users (i.e. industrial and power plants). Biomass prices are as below:

Year	Heating value	Fuel prices					
		2014		2020		2030	
Unit	Kcal/kg	USD/ton	VND/kg	USD/ton	VND/kg	USD/ton	VND/kg
Wood	3500	26.85	600	29.06	649.46	35.42	791.69
Bagasse	1850	1.12	25	1.21	27	1.48	33
Rice husk	3000	22.37	500	24.22	541.2	29.52	659.7
Straw	2800	6.71	150	7.26	162	8.86	198

Table 12: Biomass price projections. Source: (IE, 2016).

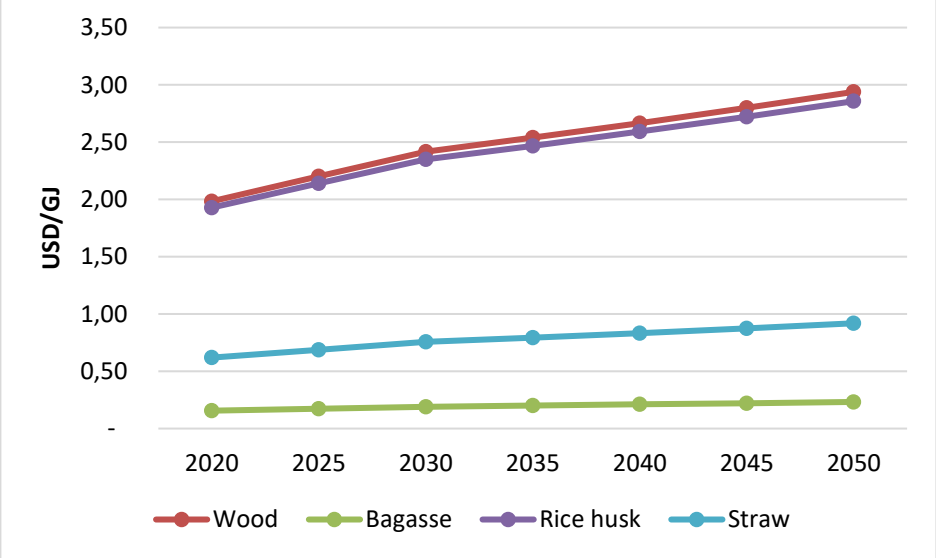

Figure 7-8: Biomass prices projections in 2020-2050.

The projections for biomass prices up to 2050 are built with simple escalation rates applied for different biomass types, considering the development trend in the period 2010-2016

USD2016/GJ	2014	2020	2025	2030	2035	2040	2045	2050
Wood	1.83	1.98	2.20	2.42	2.54	2.67	2.80	2.94
Bagasse	0.14	0.16	0.17	0.19	0.20	0.21	0.22	0.23
Rice husk	1.78	1.93	2.14	2.35	2.47	2.59	2.72	2.86
Straw	0.57	0.62	0.69	0.76	0.79	0.83	0.88	0.92

Table 13: Biomass prices projections in 2020-2050.

Appendix 1 – Fuel price forecasts, CIF Vietnam

	Imported Oil ($2016/barrel)			Imported Coal ($2016/tonne)			Imported LNG ($2016/MBtu)		
Year	SD	New policies	Current policies	SD	New policies	Current policies	SD	New policies	Current policies
2018	68.6	68.6	68.6	103.6	103.6	103.6	9.6	9.6	9.6
2019	66.2	66.2	66.2	86.6	86.6	86.6	10.1	10.1	10.1
2020	62.4	62.4	62.4	75.7	75.7	75.7	8.5	8.5	8.5
2021	60.6	61.2	61.7	75.3	75.8	75.9	8.6	8.6	8.6
2022	53.2	54.7	56.2	72.1	73.4	73.8	8.6	8.7	8.7
2023	55.7	58.6	61.4	71.7	74.0	74.8	8.7	8.8	8.9
2024	58.2	63.0	67.4	70.1	73.8	75.2	8.7	9.0	9.0
2025	60.9	67.9	74.3	67.4	72.9	74.9	8.7	9.1	9.1
2026	63.0	72.6	80.8	66.8	73.9	76.5	8.7	9.2	9.3
2027	64.9	77.7	87.8	66.2	75.0	78.4	8.8	9.4	9.5
2028	66.7	83.1	95.3	65.4	76.2	80.5	8.8	9.5	9.6
2029	68.3	88.9	103.3	64.7	77.5	82.8	8.8	9.7	9.8
2030	69.9	94.9	111.7	63.8	79.0	85.3	8.8	9.9	10.0
2031	69.2	96.7	114.1	63.6	79.2	86.3	8.8	9.9	10.0
2032	68.5	98.5	116.5	63.3	79.4	87.4	8.8	9.9	10.1
2033	67.9	100.2	118.8	63.0	79.6	88.4	8.8	9.9	10.1
2034	67.2	102.0	121.2	62.8	79.8	89.5	8.8	9.9	10.1
2035	66.6	103.8	123.6	62.5	80.0	90.5	8.8	9.9	10.2
2036	65.9	105.2	125.9	62.3	80.2	91.6	8.8	9.9	10.2
2037	65.2	106.6	128.3	62.0	80.4	92.6	8.7	9.9	10.3
2038	64.6	108.0	130.7	61.7	80.6	93.7	8.7	9.9	10.3
2039	63.9	109.3	133.1	61.5	80.8	94.7	8.7	10.0	10.3
2040	63.3	110.7	135.4	61.2	81.0	95.8	8.7	10.0	10.4
2041	63.3	110.7	135.4	60.9	81.2	96.9	8.7	10.0	10.4
2042	63.3	110.7	135.4	60.7	81.4	97.9	8.7	10.0	10.4
2043	63.3	110.7	135.4	60.4	81.6	99.0	8.7	10.0	10.4
2044	63.3	110.7	135.4	60.2	81.8	100.1	8.7	10.0	10.4
2045	63.3	110.7	135.4	59.9	82.0	101.2	8.7	10.0	10.4
2046	63.3	110.7	135.4	59.6	82.2	102.4	8.7	10.0	10.4
2047	63.3	110.7	135.4	59.4	82.4	103.5	8.7	10.0	10.4
2048	63.3	110.7	135.4	59.1	82.6	104.6	8.7	10.0	10.4
2049	63.3	110.7	135.4	58.9	82.8	105.8	8.7	10.0	10.4
2050	63.3	110.7	135.4	58.6	83.0	107.0	8.7	10.0	10.4

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