Wholesale electricity market performance monitoring

Staff working paper on 2018 approach to LCOE analysis

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AUSTRALIAN ENERGY REGULATOR

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Introduction

To inform the AER's assessment of wholesale market performance, one factor it must consider is if prices are determined in the long run by underlying costs. In its *Statement of approach*, the AER identified two possible methods of estimating costs for that assessment. In the *2018 Focus*, the AER identified that it will use levelised cost of energy (LCOE) estimates in 2018. These estimates will form part of one indicator that the AER will consider alongside a broad range of factors in assessing the effectiveness of competition and efficiency of the market.

This staff working paper is intended to provide some further clarity around staff's expected use of LCOE, some limitations, and the way we may interpret results from that analysis in the 2018 performance report. This is not a full explanation of the method the AER will use. Nor is it the AER's final approach to LCOE analysis. The AER's approach will be developed over time. The AER will publish the methodology of its analysis with the 2018 performance report.

While staff are not seeking formal stakeholder submissions, we welcome comments as we develop our approach to LCOE analysis. Comments can be provided by emailing wholesaleperformance@aer.gov.au by **Friday 6 July 2018**.

In preparing this document, we have examined many approaches from various energy markets around the world, in particular some work done in Alberta in recent years[1]. Plotted values are illustrative only.

Background

The National Electricity Law (NEL) requires the AER to monitor the wholesale market and report on its performance at least every two years.[2] It is required to identify and analyse whether:

- there is 'effective competition' within the relevant wholesale market, as defined in the NEL,
- there are features of the market that may be detrimental to effective competition with the market,
- there are features of the market that may be impacting detrimentally on the efficient functioning of the market and the achievement of the national electricity objective.

This monitoring and reporting role supports the efficient operation of the wholesale electricity market as it allows early detection of issues affecting market performance.

On 29 March 2018, as the AER implemented its new monitoring and reporting role, it published a Statement of approach and a 2018 Focus:

[1] Alberta Market Surveillance Administrator (2012), A comparison of the Long-run Marginal Cost and Price of Electricity in Alberta.

[2] National Electricity Law, Part 3 Division 1A.

- The *Statement of approach* sets out the general approach the AER will take towards fulfilling its wholesale electricity market performance monitoring functions.
- The *2018 Focus* provides an overview of the context of the 2018 performance report, the areas the AER intends to focus on for that report, and the framework and tools it intends to apply.

How we expect to approach an LCOE and price comparison

In an efficient, competitive market, with free entry and exit, we expect prices to move broadly in line with underlying costs. In this market, if prices persist above underlying costs, entrepreneurs will see an opportunity and enter the market, driving the price down. Alternatively, if prices persist below underlying costs, it will eventually become unprofitable for high-cost firms to remain in the market, and they will leave. Over time this will cause the price to rise.

However, the underlying costs faced by a new entrant are unknown. Therefore, to undertake a comparison of prices and costs, we must estimate the costs of establishing new generation. One approach is to estimate the LCOE.[3]

A LCOE and price comparison compares a new entrant generator's costs, levelised across the time it operates, to the average price that generator could expect to receive depending on when it produces. If that price exceeds the costs, for any capacity utilisation rate, then there is an incentive for new entry.

We expect comparing LCOE and price to act as a high level indicator. If our analysis suggests the opportunity for new entry, and we do not see this occurring, we will need to analyse why.

As outlined in the *Statement of approach*, there are a number of assumptions and limitations behind LCOE analysis. Where possible, we note these throughout this working paper. Recognising these assumptions and limitations, we will be careful not to over-emphasise the results of LCOE analysis, and not consider it in isolation. Rather, we will consider any results in conjunction with the results of the other tools we will use.

What is LCOE?

LCOE measures the average cost of building and operating a new generator of a specific technology over its assumed life cycle. In estimating LCOE, the costs of investment and operation of the new generator are recovered across the time it is in operation. It follows that LCOE can be seen as the average minimum cost for a new generator to sell its electricity in order to break even over its lifetime.

Generators face variable and fixed costs, LCOE includes estimates for both.

What are the assumptions underlying LCOE?

The capacity utilisation rate (or capacity factor) is one of the most important input parameters in calculating LCOE values. The capacity utilisation rate is the amount of energy produced by a generator as a proportion of its maximum possible production. This parameter is significant in the LCOE calculation as the fixed costs associated with generation are

[3] The *Statement of approach* discusses alternate methods for estimating costs.

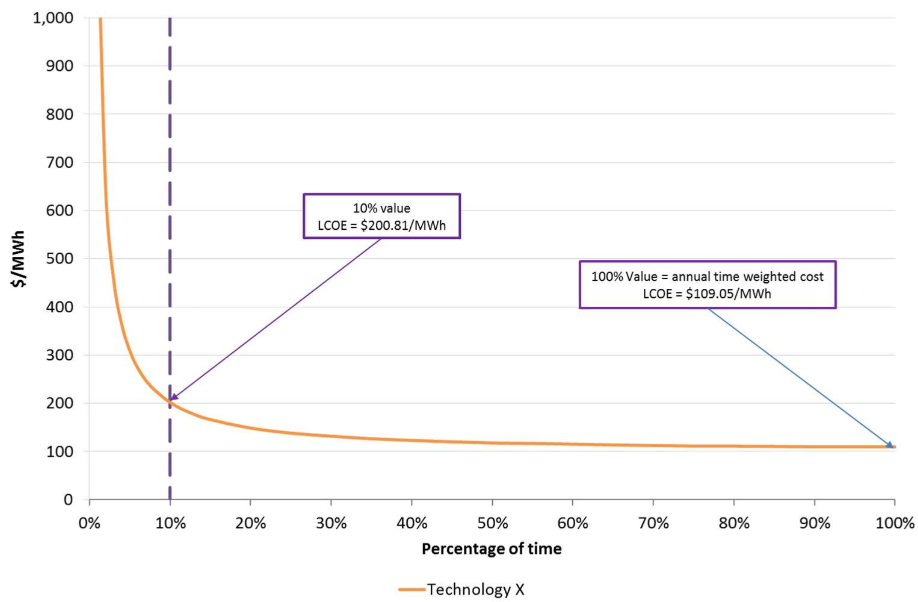
allocated across each megawatt of energy produced. For this reason, we propose to calculate LCOE across a full range of potential capacity utilisation rates. This will result in a curve of possible LCOE values, rather than a single LCOE figure.

Other factors important in the LCOE estimations include:

- fuel costs and escalations
- capital costs
- expected years of service
- construction lead time and interest during construction
- funding arrangements, including debt and equity rates and ratios
- heat rate or energy efficiency
- annual and long term maintenance rates
- typical operations and maintenance costs.

It should be noted that this does model not incorporate costs such as start-up or shut-down or aging costs associated with rapid change in output. Furthermore it does not consider the loss in efficiency that part load operation may impose. Once the necessary new entrant assumptions for a particular technology have been developed, we can illustrate the LCOE as a function of the capacity utilisation rate, as shown in Figure 1.

Figure 1 – Technology X LCOE curve



As expected, the LCOE curves exhibit a downward-sloping relationship between costs and the capacity utilisation rate. This happens as the fixed costs are spread over an increasing amount of production.

In Figure 1, for a generator producing 10 per cent of the year, its levelised costs are around $200/MWh. Similarly, if the generator in Figure 1 produces all the energy it can for the entire year, its levelised costs equate to the value of the LCOE curve evaluated at 100 per cent of hours or around $109/MWh.

What prices are relevant?

A key issue with using prices as a point of comparison with estimates of underlying costs is that the spot price for each trading interval varies. So, depending on when a generator is operating, it will receive a different average price for its production. If it were to operate at full power for the entire year and receive every price, on average it would receive the time weighted average price for the year.

However, in most cases generators do not run at full output or for the entire year. Many operational requirements may contribute to this: the need to reduce output to match demand targets, fuel availability, maintenance schedules or unplanned outages.

A generator will generally only run when prices are at a level that allow it to at least recover its costs. Therefore, it is important to account for the average price a generator may receive over the hours that it runs, to determine potential earnings. For example:

- a baseload generator that operates almost continuously should receive close to the annual time weighted average price. In running almost continuously, it will receive not only those high prices, but it may also choose to operate through some potentially low or negative price periods to avoid costly short term shutdowns or restarts.
- a peaking generator that only operates at times when the price exceeds $5000/MWh should receive a higher average price than a baseload generator that operates much more frequently.

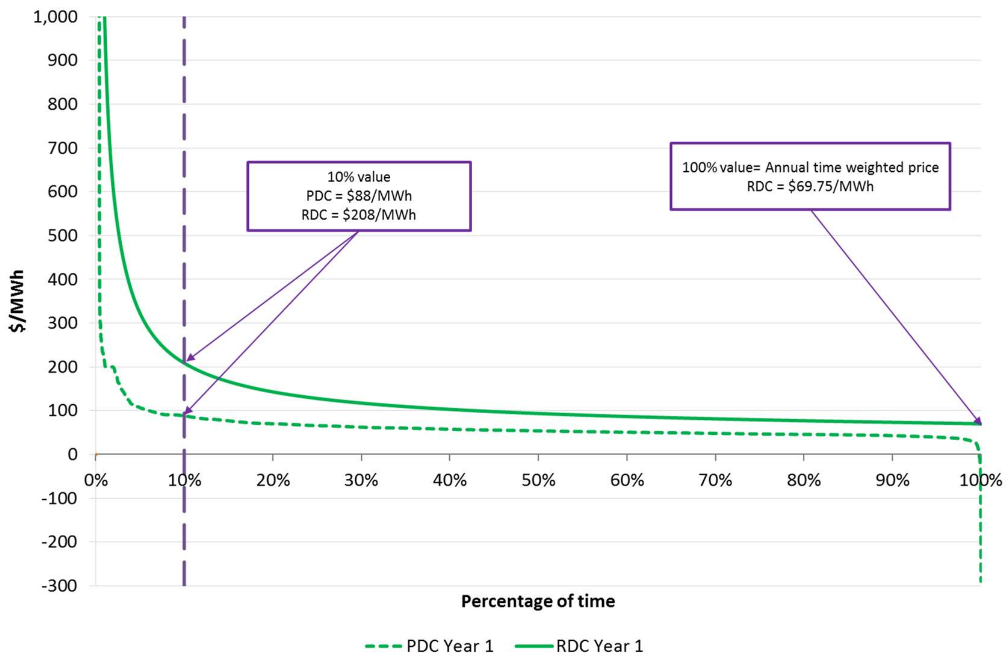
In recognition of the relative contribution of the changing spot price to the average annual price, we construct a price duration curve (PDC) and from that we derive a revenue duration curve (RDC) (see the hypothetical example in Figure 2).

The PDC illustrates the proportion of hours in which prices exceed a given level.

The RDC is derived from the PDC and indicates the average price that prevails in those hours. In an ideal sense it determines the average spot earnings a participant could receive by operating only when prices are at, or above, a particular level. The RDC is a function of the PDC.

The PDC and RDC need to be read together. For example, if a generator were to only operate during the 10 per cent of trading intervals when the spot price exceeded $88/MWh, its average earnings would be priced at $208/MWh for each megawatt it produced. This is shown above at the purple dashed line of intersection.

Figure 2 – PDC and RDC curves



Comparing the RDC and LCOE curves

Illustrating the LCOE curve on the same graph as the RDC and PDC curves provides a high-level visual indicator of the relationship between potential revenue and operating costs. If the RDC exceeds the LCOE at any point, then there **may** be an opportunity for a generator of that technology to fully recover its costs in that year.

A prospective generator will not enter the market unless it expects that it will fully recover its costs. In theory, if an opportunity for cost recovery remains sustained, this should be part of the market signal for the entry of the relevant technology type. If entry does not occur, there may be factors other than price impeding the new entry that warrant further analysis. We will explore these factors in our barriers to entry and other analysis in the 2018 performance report.

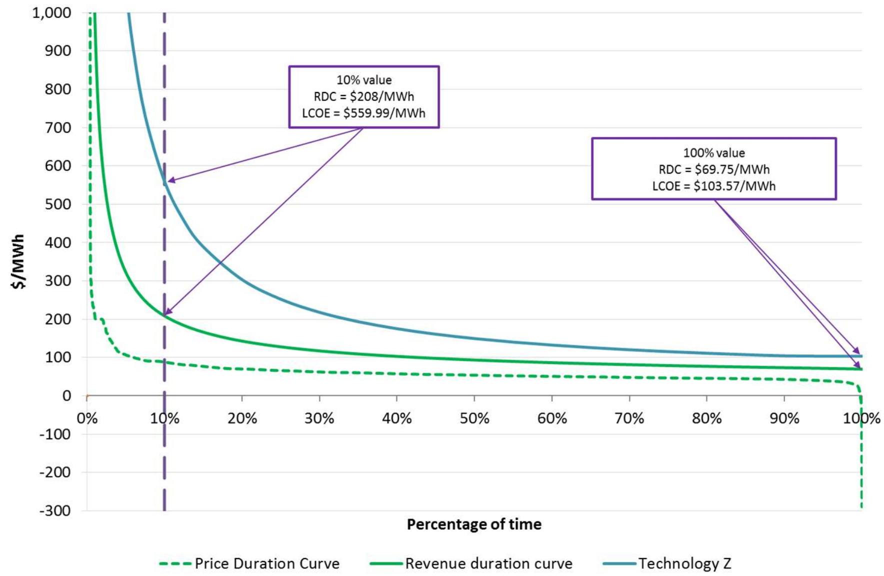
Example comparisons

In the simple examples below, we have compared a range of LCOE curves for hypothetical technologies with the PDC and RDC from above.

Example 1 - Technology Z LCOE curve exceeds RDC

In Figure 3, we see the LCOE curve of Technology Z exceeding the RDC for all potential capacity utilisation rates. As the LCOE curve for this technology is always above the RDC, this comparison indicates that, based on the historical prices from that year, Technology Z could not recover its costs. Therefore, we would not expect to see new entry for Technology Z.

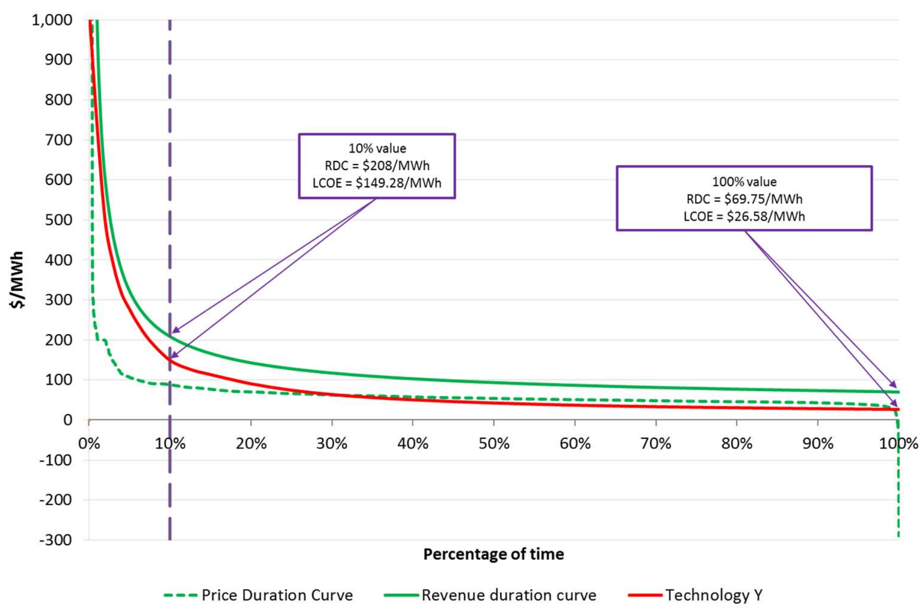
Figure 3 – Example 1



Example 2 - RDC exceeds Technology Y LCOE curve

In Figure 4, we see the RDC exceeding the LCOE curve of Technology Y for all potential capacity utilisation rates. As potential revenue exceeds expected costs, this shows that an opportunity exists for Technology Y to recover its costs for this year. If this situation was sustained for several years, we would expect new entry of that plant type. If there was no new entry, it would support a conclusion that there are other potential impediments requiring further investigation.

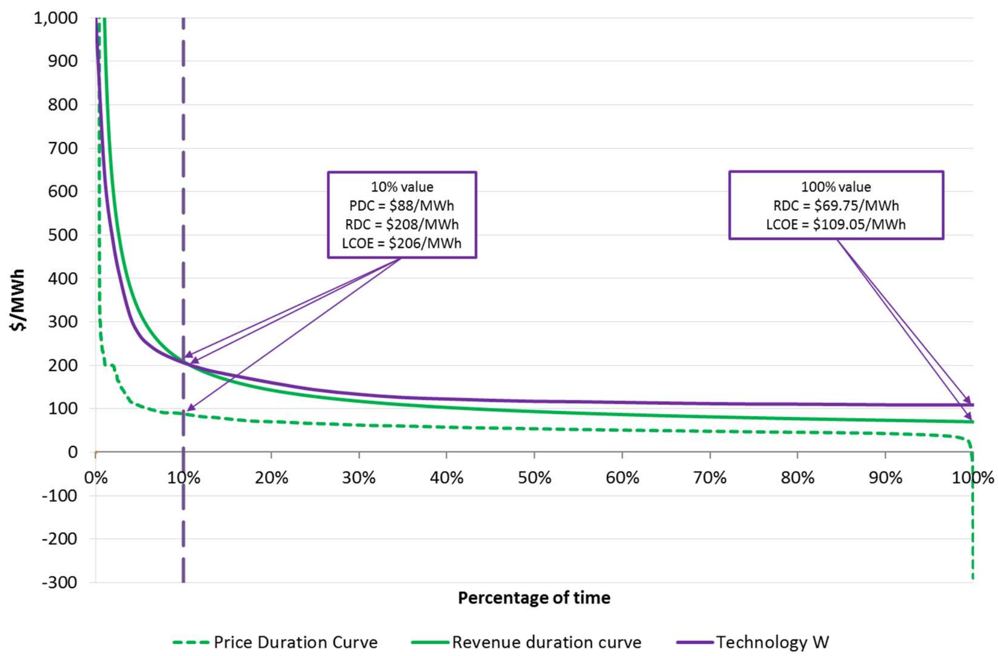
Figure 4 – Example 2



Example 3 - Technology W LCOE curve intersects RDC

In Figure 5, we see the RDC exceeding the LCOE curve of Technology W for capacity factors less than 10 per cent. This implies that, for this year, there exists the opportunity for a plant of technology W to recover its costs providing it operates during times when spot prices exceed around $88/MWh (PDC value at 10 per cent). At these times, its average revenue would be at least $208/MWh, which would be sufficient to recover its levelised costs of $206/MWh. If this situation was sustained for several years, there may be some limited expectation that, assuming a mode of operation such as that were possible, a new entrant utilising that plant type may be viable. This situation in particular would put more emphasis on some of the simplifying assumptions on which this model relies but if there was not at least increased consideration of new projects utilising this technology then further investigation may be warranted.

Figure 5 - Example 3



When the RDC exceeds the LCOE curve at any point

It is important to note that the conclusions of our analysis of the second and third example are the same. That is, the expectation that a generator could recover its costs holds if the RDC exceeds the LCOE curve at *any point*. As we mentioned above, if there is any possibility for a new generator to operate such that potential revenue will exceed costs of operation, we expect entrepreneurs to seize the opportunity and enter the market.

In practice, generators will naturally structure their bids such that they are dispatched in a manner that tends towards an optimal level, where the difference between revenue and costs is maximised. Relative to our analysis, if that optimal point on the RDC is below the LCOE curve, then all points of RDC should be below the LCOE, and there would be no market signal for new entry. Conversely, if any part of the RDC is above the LCOE, then that optimal point will also be above the LCOE. When revenue exceeds costs for a sustained period, there would be a market signal for new entry of that plant type.

We must consider potential limitations

This simplified discussion does not delve deeply into the economics underlying LCOE calculation and comparison. It is important to note that there are a number of potential limitations with this sort of analysis, for example:

- This simple comparison assumes a generator has the ability to choose bidding strategies that influence when it generates, allowing it to target certain production levels. This has implications for its application to intermittent technologies like solar and wind, which have limited choice over when to generate, unless combined with firming technologies such as batteries or other forms of storage. These generators typically offer capacity at low, even negative, prices in order to guarantee dispatch. Intermittent renewable generators acting as price takers typically earn less for the same capacity factor than compared to a flexible, conventional generator that can operate at any time.

  With the greater penetration of intermittent, low-emission energy sources and the greater need for dispatchable and firming technologies, even traditional types of generation may be packaged with new technologies that will change the ways these technologies operate in the future.

- For simplicity, LCOE estimates currently exclude a generator's start-up costs. These costs are proportional to the number of times a generator is started, and depend on a number of factors. While the number of times a generator starts can relate to its capacity utilisation rate, the relationship is not simple. For example, a generator that operates during the 10 per cent of trading intervals when the spot price exceeds $88/MWh may only incur start-up costs once, one thousand times, or any number of possibilities.

- The PDC and RDC curves do not consider the impact of new entrants on prices or costs. Typically, we would expect a new entrant to alter the shape of the PDC and RDC, reflecting their contribution. For simplicity, our analysis assumes that the new entrant is too small to affect the price. This is because adjusting the curve to match the potential impact of a larger new entrant would require market simulation. We could, to some degree, overcome this by constructing a premium factor, which would provide an allowance for the change to the PDC and RDC that a real new entrant may make, but every potential developer would have unique criteria against which this premium were based.

- This comparison excludes transmission constraints. While we assume a generator can target certain production levels through its bidding strategies, congestion and constraints in the transmission network can be a limiting factor. To the extent constraints are binding, a generator may not get dispatched when it expects, to the level it hopes or for the price it wants, impacting its revenue.

- This analysis focusses on new entrant generators that only sell electricity into the spot market. New entrants would consider other potential sources of revenue, such as ancillary services in establishing a business model. They would also need to consider risk management options, such as financial hedging, which would affect their revenues and bidding strategies. These other factors could affect the attractiveness of any new entry.

Given the above potential limitations, we will be careful to not attach too much weight to the results of the analysis. For example, we would not conclude the market was not effectively competitive from the results of this analysis alone. Rather, results would signpost the need for further investigation into the existence of market power, barriers to entry or other potential impediments that may explain the outcome.