Technical Assessment Report

Review of GenCost 2023-24

Executive Summary

A technical assessment of GenCost 2023-24 is presented and the purpose of the assessment is to evaluate the assumptions used in GenCost 2023-24 to calculate the levelised cost of electricity (LCOE) for the following generation technologies:

a. Black coal.
b. Onshore wind.
c. Large-scale solar PV.

In particular, the following parameters are discussed in relation to the different means of generating electricity:

a. Economic life (or design life).
b. Capacity factor.
c. Output degradation.

In addition to the above, the costs for black coal are discussed in greater detail and the cost and type of nuclear is also discussed.

It is concluded that the GenCost 2023-24 parameters used for coal are too pessimistic and that the parameters used for onshore wind and Large-scale solar PV are overly optimistic. Consequently, it is recommended that they be amended, which would result in a lowering of the LCOE for coal and an increase in the LCOE for onshore wind and large-scale solar PV.

In particular, GenCost 2023-24 appears to be inconsistent because it uses the higher cost of advanced ultra-supercritical coal (AUSC), but it uses the lower capacity factors of conventional coal plants. Therefore, it is recommended that the capacity factors should be in accordance with the technology that is being used in the cost analysis.

Consequently, the parameters for coal should be amended to be consistent with the technology being considered in the LCOE calculation. Namely, if the cost of AUSC is to be used in the LCOE calculation then the capacity factors for AUSC should also be used to maintain consistency in the calculation.

The following recommendations are also made regarding the economic life, capacity factor and output degradation for black coal, onshore wind, and large-scale solar PV.

Type of Generation	Long Lifespan (years)	Average Lifespan (years)	Short Lifespan (years)
Black Coal	60	45	30
Onshore Wind	25	20	15
Large-Scale Solar PV	25	20	15

Table 1: Economic Lifespan for Black Coal, Onshore Wind and Large-Scale Solar PV

Type of Generation	High Capacity Factor	Average Capacity Factor	Low Capacity Factor
Black Coal	95%	87.5%	80%
Onshore Wind	44%	32%	20%
Large-Scale Solar PV	29%	23%	19%

Table 2: Capacity Factors for Black Coal, Onshore Wind and Large-Scale Solar PV

Type of Generation	High Output Degradation p.a.	Average Output Degradation p.a.	Low Output Degradation p.a.
Black Coal	0.097%	0.093%	0.089%
Onshore Wind	1.8%	1.6%	1.4%
Large-Scale Solar PV	1.5%	1.0%	0.5%

Table 3: Output Degradation for Black Coal, Onshore Wind and Large-Scale Solar PV

It is noted that GenCost 2023-24 does not consider output degradation. However, this omission leads to a significant overestimate of the power output of onshore wind and large-scale solar PV, with the consequential underestimate of the LCOE. Therefore, it is recommended that output degradation be included for all types of electricity generation in GenCost 2023-24.

It is also recommended that the capital cost of coal be reduced from $5,722/kW to either $4,680/kW in accordance with Aurecon (2023) for an advanced ultra-supercritical (AUSC) power station or $2,400/kW in accordance with Kogan Creek in Queensland for a supercritical (SC) power station. These capital costs are summarised in Table 4.

Source	Plant Type	Capital Cost ($/kW)	Ratio (GenCost 2023-24/Source)
GenCost 2023-24	AUSC	5,722	100%
Aurecon (2023)	AUSC	4,680	122%
Kogan Creek, QLD	SC	2,400	238%

Table 4: Comparison of Capital Costs for Black Coal

Furthermore, the GenCost 2023-24 fuel costs for black coal are 253% to 300% of those presented in AEMO (2023) as summarised in Table 5.

Source	High Cost	Low Cost
GenCost 2023-24	$11.3/GJ	$4.30/GJ
AEMO (2023)	$4.47/GJ	$1.43/GJ
Ratio (GenCost 2023-24/AEMO)	253%	300%

Table 5: Comparison of Fuel Costs for Black Coal

Consequently, it is recommended that the GenCost 2023-24 fuel costs be reduced to those presented in AEMO (2023).

Finally, regarding nuclear, only one (now cancelled) SMR plant is considered in the GenCost 2023-24 LCOE calculation, which has resulted in a very high cost estimate. Furthermore, IEA (2020) states that new-build nuclear has a similar LCOE to onshore wind and large-scale solar PV.

Therefore, it is recommended that a more diverse range of nuclear technology be presented in GenCost 2023-24. For example, refer to IEA (2020) and/or the modular reactors that have been deployed in China and Russia. Alternatively, it is recommended that nuclear be deleted.

Contents

1 Review in Context

1.1 Background

The series of GenCost reports have been produced by CSIRO since 2018 and these reports have been used to formulate the Australian government's policy for electricity generation. In particular the GenCost reports state that variable renewables have the lowest cost range of any new-build technology for electricity generation.

1.2 Purpose of the Assessment

The purpose of this assessment is to evaluate the assumptions used in GenCost 2023-24 to calculate the levelised cost of electricity (LCOE) for the following generation technologies:

a. Black coal.
b. Onshore wind.
c. Large-scale solar PV.

2 Technical Assessment

2.1 Summary

This assessment examines the assumptions used in GenCost 2023-24 to calculate the levelised cost of electricity (LCOE). In particular, the following parameters are discussed in relation to the different means of generating electricity:

a. Economic life (or design life).
b. Capacity factor.
c. Output degradation.

In addition to the above, the costs for black coal are discussed in greater detail and the costs presented in other literature are compared with those assumed in GenCost 2023-24.

Furthermore, the cost and type of nuclear is also discussed.

3 Economic Life

3.1 Introduction

Apx Table B.9 of GenCost 2023-24 presents the data assumptions for the economic life that are used in the LCOE calculations, and they are summarised as follows:

a. Black coal = 30 years.
b. Onshore wind = 25 years.
c. Large-scale solar PV = 30 years.

The note to Apx Table B.9 of GenCost 2023-24 states that, *"Economic life is the design life or the period of financing. Total operational life, with refurbishment expenses, is not included in the LCOE calculation…"*. However, GenCost 2023-24 curently does not include short and long lifespans for the generators. Therefore, it is recommended that short and long lifespans be included, as is done with some of the other high and low parameters in the LCOE analysis.

The lifespans for the above generators are discussed as follows.

3.2 Economic Life of Coal

3.2.1 Discussion of Economic Life of Coal

Table 4-27 of (Aurecon, 2023) presents and economic life (design life) of 30 years and a technical life (operational life) of 50 years for coal generation. However, the 30-year economic life for coal generation used in GenCost 2023-24 and Aurecon (2023) appears to be too low.

For example, Figure 3 and Table 1 of McConnell (2016) shows that the average lifespan of coal-fired power stations in Australia is approximately 50 years. However, there are several examples of coal-fired power stations with an economic life longer that is significantly longer than the 30 years value used in GenCost 2023-24 , namely:

a. Liddell, NSW, was commissioned in 1971 and decommissioned in 2023 resulting in an economic life of 52 years.
b. Muja, WA, was commissioned in 1966 and is expected to be decommissioned in 2029, which would result in an economic life of 63 years.
c. Eraring, NSW, was commissioned in 1982 and is scheduled to be decommissioned in 2025, which would result in an economic life of 43 years. However, the NSW government is currently in negotiations to keep Eraring operating for several more years.

3.2.2 Conclusions & Recommendations from Economic Life of Coal

From the foregoing, it would appear that the 30-year economic for life coal-fired power used in GenCost 2023-24 is too short. It is apparent that several coal-fired power stations are economically operating beyond 50 years. Therefore, it is recommended that GenCost 2023-24 use the following lifespans in the LCOE calculation for coal-fired power stations:

a. Long lifespan = 60 years.
b. Average lifespan = 45 years.
c. Short lifespan = 30 years.

3.3 Economic Life of Onshore Wind

3.3.1 Discussion of Economic Life of Onshore Wind

Table 4-2 of (Aurecon, 2023) presents an economic life (design life) of 20-25 years and a technical life (operational life) of 30-35 years for onshore wind generation. However, the 30-35 years economic life for onshore wind generation used in GenCost 2023-24 and Aurecon (2023) appears to be too high because other references state a significantly lower design life for onshore wind.

For example, Hughes (2012) suggests a 15-year economic life for wind turbines and Coultate & Hornemann (2018) explain why wind turbines do not last longer than 20 years.

3.3.2 Conclusions & Recommendations from Economic Life of Onshore Wind

From the foregoing, it would appear that the 25-year economic life for onshore wind generation used in GenCost 2023-24 is too long, because other references, namely, (Aurecon, 2023), Hughes (2012) and Coultate & Hornemann (2018) state significantly shorter lifespans. Therefore, it is recommended that GenCost 2023-24 use the following lifespans in the LCOE calculation for onshore wind generation:

a. Long lifespan = 25 years.
b. Average lifespan = 20 years.
c. Short lifespan = 15 years.

3.4 Economic Life of Large-Scale Solar PV

3.4.1 Discussion of Economic Life of Large-Scale Solar PV

As stated earlier, Apx Table B.9 of GenCost 2023-24 uses an economic life for large-scale solar PV of 30 years. Additionally, Table 4-11 of (Aurecon, 2023) presents an economic life (design life) of and a technical life (operational life) of 30 years for large-scale solar PV. However, the 30-year economic life for large-scale solar PV generation used in GenCost 2023-24 and Aurecon (2023) appears to be too high because other references state a significantly lower economic life.

For example, Tan et al (2022) state that the practical lifetime as solar PV is 15-20 years, and they note that this is, *"…significantly shorter than the industry standard of 25 years, which is based on performance guarantees of 80% power output after 25 years of operation."*

Note that the guarantee of 80% power out after 25 years of operation assumes degradation of output with time. However, output degradation is not considered in GenCost 2023-24. Therefore, output degradation is discussed in greater detail later in this report for the different types of power generation.

3.4.2 Conclusions & Recommendations from Economic Life of Large-Scale Solar PV

From the foregoing, it would appear that the 30-year economic life for large-scale solar PV is too long. Therefore, it is recommended that GenCost 2023-24 use the following lifespans in the LCOE calculation for large-scale solar PV:

a. Long lifespan = 25 years.
b. Average lifespan = 20 years.
c. Short lifespan = 15 years.

4 Capacity Factors

4.1 Introduction

Apx Table B.9 of GenCost 2023-24 presents the data assumptions for the capacity factors that are used for the LCOE calculations, and they are summarised as follows:

a. Coal (black and brown):
    High assumption = 89%.
    Low assumption = 59%.
b. Onshore wind:
    High assumption = 48%.
    Low assumption = 29%.
c. Large-scale PV:
    High assumption = 32%.
    Low assumption = 19%.

The capacity factors for each of these generators are discussed in greater detail as follows.

4.2 Capacity Factors for Coal

4.2.1 Discussion of Capacity Factors for Coal

The high and low capacity factors of 89% and 59% respectively are reasonable for existing for coal-fired power stations. However, they are too low for new supercritical and advanced ultra-supercritical power stations as discussed below. Furthermore, the capital cost of $5,722/kW in Apx Table B.9 appears to be based on a relatively expensive advanced ultra-supercritical power station, which would result in a cost of approximately $4B for a 700 MW power station.

Additionally, Table 4-26 Aurecon (2023) states that effective annual capacity factor of advanced ultra-supercritical power stations is 93%, Furthermore, a literature review indicates that these power stations typically operate with capacity factors in th 80%-95% range. Consequently, the high and low capacity factors of 95% and 80% respectively are reasonable for advanced ultra-supercritical power stations.

Note that the high value of 95% above is similar to the Aurecon (2023) Table 4-26 value of 93% for the effective annual capacity factor of advanced ultra-supercritical power stations.

4.2.2 Conclusions & Recommendations from Capacity Factors for Coal

It is evident from the foregoing that the high and low capacity factors of 89% and 59% respectively are reasonable for existing for coal-fired power stations, but that they are too low for new advanced ultra-supercritical power stations.

Therefore, it is recommended that the following capacity factors be used in the GenCost 2023-24 LCOE calculations for new advanced ultra-supercritical power stations:

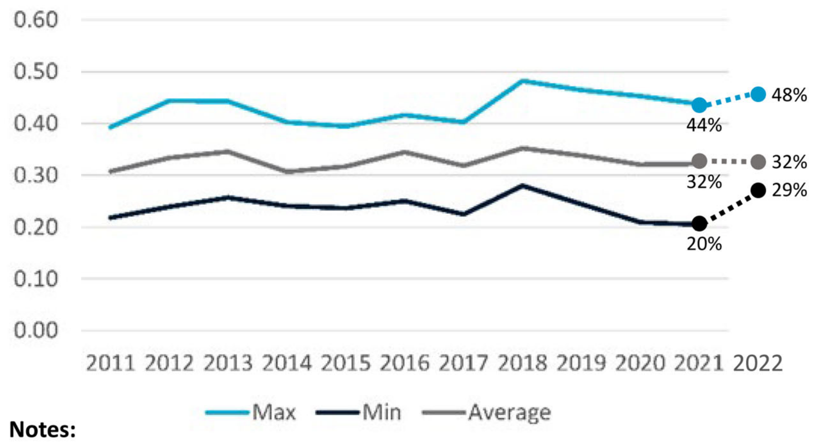
a. High capacity factor = 95%.
b. Average capacity factor = 87.5%.
c. Low capacity factor = 80%.

4.3 Capacity Factors for Onshore Wind

4.3.1 Discussion of Capacity Factors for Onshore Wind

GenCost 2023-24 Apx Table B.9 Data assumptions for LCOE calculations shows a high capacity factor of 48% and a low factor of 29%. Furthermore, Figure 4.1 (adapted from GenCost 2022-23 Apx Figure D.1) shows that the maximum, minimum and average capacity factors for onshore wind are 44%, 20% and 32% respectively.

Consequently, the high capacity factor of 48% for onshore wind used in GenCost 2023-24 is not unreasonable when compared with the value of 44% from Figure 4.1, because new wind turbines should have a higher capacity factor than existing turbines. Nevertheless, Hughes (2012) does note that the capacity factor of newer (larger) turbines is less than that of older (smaller) turbines. Therefore, it would be prudent to adopt the 44% value in Figure 4.1.



Notes:

1. Max, min and average capacity factors for 2021 are from GenCost 2022-23.
2. Max and min capacity factors for 2022 are from GenCost 2023-24.
3. Average capacity factor for 2022 is the mean of Lang (2024) and Rutovitz et al (2017).

Figure 4.1: Capacity Factors for Onshore Wind (Adapted from GenCost 2022-23)

However, the low capacity factor of 29% appears to be untenable because it is too near to the average value as discussed below.

Lang (2024) presents average capacity factors for onshore wind 30.0% (latest 52 weeks) and 30.3% (latest 274 weeks). Similarly, Rutovitz et al (2017) state that wind farms in Australia have an average capacity factor of 33%. These values are near to the average value of 32% in Figure 4.1. Therefore, it is reasonable to adopt the GenCost 2022-23 average capacity factor of 32% for onshore wind, which is the same as the mean of Lang (2024) and Rutovitz et al (2017).

Furthermore, assuming a normal distribution and using a high of 48% and an average of 32%, would result in a low capacity factor of 16%. However, using the 20% value presented in Apx Figure D.1 of GenCost 2022-23 (Figure 4.1 above) is slightly high, but it is not unreasonable.

4.3.2 Conclusions & Recommendations from Capacity Factors for Onshore Wind

The following conclusions and recommendations are made from the review of the capacity factors for onshore wind:

a. The high capacity factor of 48% presented in GenCost 2023-24 is not unreasonable but it would be prudent to adopt the adopt the 44% value in Figure 4.1 because Hughes (2012) has highlighted that that the capacity factor of newer (larger) turbines is less than that of older (smaller) turbine.
b. An average capacity factor of 32% is reasonable.
c. The low capacity factor of 29% is untenable because it is too near to the average value 32%, and it is not consistent with a normal distribution. Therefore, it is recommended that the 29% value be replaced by the 20% value presented in Apx Figure D.1 of GenCost 2022-23 (Figure 4.1 above).

In summary, it is recommended that the following capacity factors be used in the GenCost 2023-24 LCOE calculations for onshore wind:

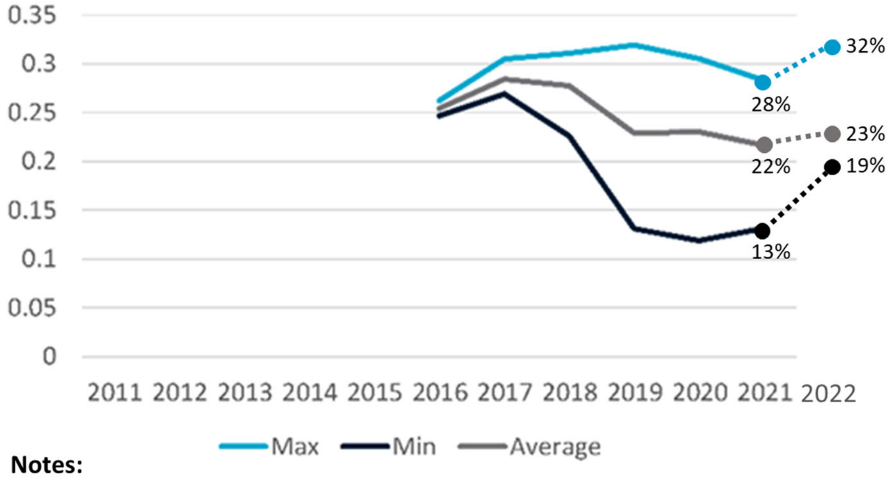
a. High capacity factor = 44%.
b. Average capacity factor = 32%.
c. Low capacity factor = 20%.

4.4 Capacity Factors for Large-Scale Solar PV

4.4.1 Discussion of Capacity Factors for Large-Scale Solar PV

Table 4-10 of Aurecon (2023) states that effective annual capacity factor of large-scale solar PV is 29% (this value is based on a system installed in regional NSW).

However, GenCost 2023-24 Apx Table B.9 Data assumptions for LCOE calculations shows a high capacity factor of 32% and a low factor of 19% for large-scale solar PV. Furthermore, Figure 4.2 (adapted from GenCost 2022-23 Apx Figure D.1) shows that the maximum, minimum and average capacity factors for large-scale solar PV are 28%, 13% and 23% respectively.



Notes:

1. Max, min and average capacity factors for 2021 are from GenCost 2022-23.
2. Max and min capacity factors for 2022 are from GenCost 2023-24.
3. Average capacity factor for 2022 is from Lee (2023).

Figure 4.2: Capacity Factors for Large-Scale Solar PV (Adapted from GenCost 2022-23)

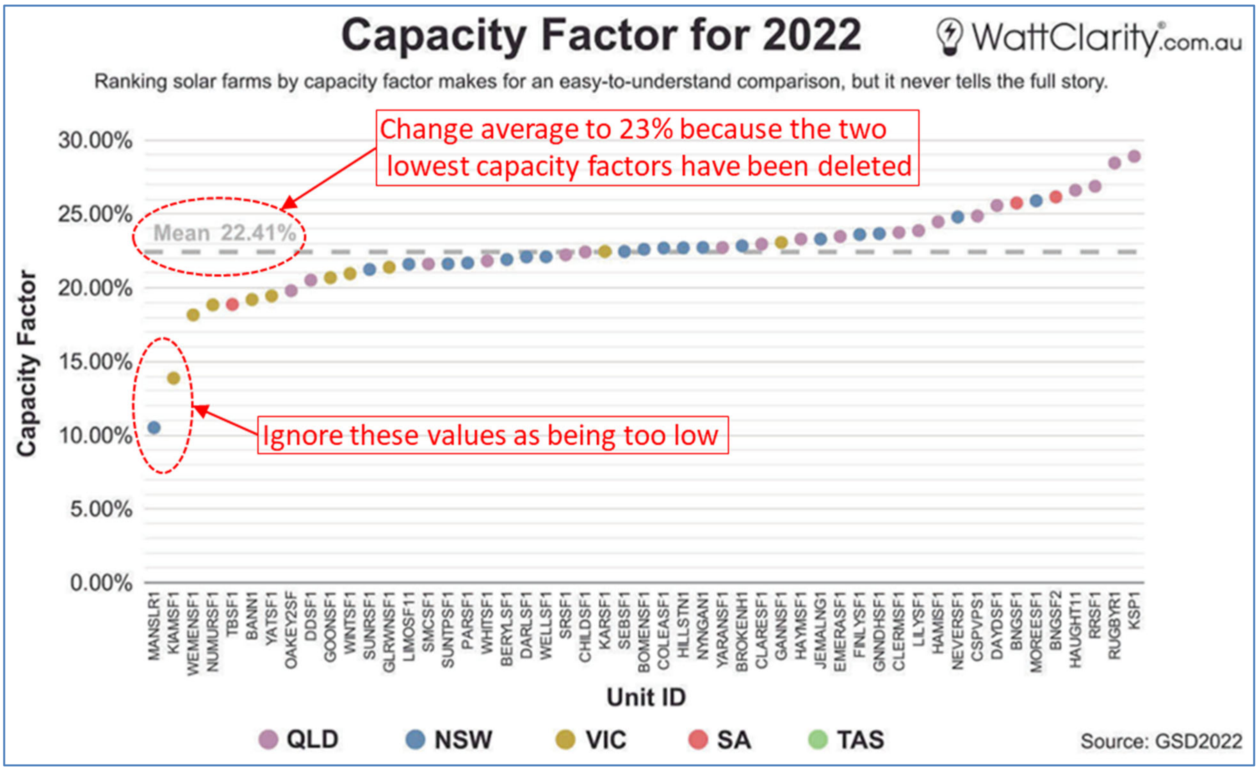
Additionally, Lee (2023) presents capacity factors shown in Figure 4.3 that are similar to the high and low values in Figure 4.2. Consequently, if we were to ignore the two low values in Figure 4.3, the resulting capacity factors would be 29%, 18% and 23% for the maximum, minimum and average respectively.

The low capacity factors of 18% and 19% in Figure 4.3 are near to the low value of 19% used in GenCost 2023-24. However, the high capacity factor of 32% in GenCost 2023-24 is 10% greater than the high value of 29% presented in Figure 4.3. Consequently, it is suggested that the high capacity factor of 29% from Figure 4.3 be used in GenCost 2023-24.

4.4.2 Conclusions & Recommendations from Capacity Factors for Large-Scale Solar PV

From the foregoing, it is recommended that the following capacity factors be used in the GenCost 2023-24 LCOE calculations for large-scale solar PV:

a. High capacity factor = 29%.
b. Average capacity factor = 23%.
c. Low capacity factor = 19%.



Change average to 23% because the two lowest capacity factors have been deleted

Ignore these values as being too low

Source: GSD2022

Figure 4.3 Capacity Factors for Large-Scale Solar PV (Adapted from Lee, 2023)
***Note:** Comments in red have been added to the original diagram.*

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5 Output Degradation

5.1 Introduction

All forms of equipment suffer from a degradation thus reducing the efficiency and output. However, GenCost 2023-24 does not consider output degradation for the various forms electricity production, and this omission is discussed in greater detail below.

5.2 Output Degradation in Coal

5.2.1 Discussion of Output Degradation in Coal

Table 4-26 of Aurecon (2023) presents a zero annual degradation for advanced ultra-supercritical coal. However, this value appears to be too low.

For example, Parson Brinckerhoff (2011) suggest a degradation in output from coal of 2.2% over a design life of 25 years and Mott McDonald (2010) suggest a degradation of 2.4%. These values equate to annual degradation rates of 0.089% and 0.097% respectively.

5.2.2 Conclusions & Recommendations from Output Degradation in Coal

From the foregoing, it is recommended that following annual degradation rates be used in the GenCost 2023-24 LCOE calculations for advanced ultra-supercritical coal:

a. High degradation rate = 0 097%.
b. Average degradation rate = 0.093%.
c. Low degradation rate = 0.089%.

5.3 Output Degradation in Onshore Wind

5.3.1 Discussion of Output Degradation in Onshore Wind

Table 4-1 of Aurecon (2023) presents a linear annual degradation of 0.1% p.a. for onshore wind. However, this value appears to be too low by an order of magnitude as discussed below.

Staffell & Green (2014) state that modern wind turbines in the UK and Denmark exhibit an annual degradation in output of 1.6% ± 0.2%. This unrecoverable loss is attributed to gradual deterioration, such as fouling of the blades (which inhibits the aerodynamic performance) and a gradual reduction in component efficiencies (gearbox, bearings, and generator). Additionally, Staffell & Green (2014) state that these losses may not be recoverable by maintenance procedures, but only recoverable by component replacement.

Furthermore, Hughes (2012) presents significantly worse degradation values than Staffell & Green (2014) for the UK but similar values to the Staffell & Green (2014) values for Denmark. Therefore, the Staffell & Green (2014) annual degradation rate of 1.6% ± 0.2% should be considered to be a best-case scenario. Moreover, Staffell & Green (2014) state that, *"This level of degradation reduces a wind farm's output by 12% over a twenty year lifetime, increasing the levelised cost of electricity by 9%."*

5.3.2 Conclusions & Recommendations from Output Degradation Onshore Wind

The above level of degradation is not insignificant, and it is concluded that it should be included in the LCOE calculation for onshore wind. Therefore, it is recommended that the following annual degradation rates be used in the GenCost 2023-24 LCOE calculations for onshore wind:

a. High degradation rate = 1.8%.
b. Average degradation rate = 1.6%.
c. Low degradation rate = 1.4%.

5.4 Output Degradation in Large-Scale Solar PV

5.4.1 Discussion of Output Degradation in Large-Scale Solar PV

Table 4-10 of Aurecon (2023) presents an annual degradation of 0.4% p.a. for large-scale solar PV. Additionally, regarding the degradation rate of solar PV, AEC (2022) state that the *"Numbers vary from approximately 0.1 per cent to 1 per cent depending on the system. The Australian Energy Council has used 0.5 per cent as a constant degradation rate for all LCOE calculations."* However, these values appear to be too low when compared with the following literature.

Aboagye et al (2021), Daher et al (2023) and Sanchez et al (2021) present a wide range of degradation rates from large-scale solar PV. Their degradation values range from a low of 0.53% to a high of 1.67%, depending on the type of solar panel and the climate to which it is exposed. In particular, Dimish & Alrashidi (2020) found that the degradation rate for large-scale solar PV sites installed in Australia was in the range from 1.35% to 1.46% p.a.

Furthermore, Table 3 of Sanchez et al (2021) presents the following values for annual and total power degradation for different solar PV projects:

a. After 22 years in operation: Total degradation = 30.9%, with an annual degradation rate = 1.4%.
b. After 17 years in operation: Total degradation = 11.5%, with an annual degradation rate = 0.96%.
c. After 15 years in operation: Total degradation = 9.0%, with an annual degradation rate = 0.53%.

It is evident from the above, that the total power degradation of 30.9% is very significant for the high rate of 1.4% p.a. Additionally, the total power degradation of 9.0% in large-scale solar PV power output is not insignificant even for the low degradation rate of 0.53% p.a.

5.4.2 Conclusions & Recommendations from Output Degradation Large-Scale Solar PV

It is concluded that the power degradation in large-scale solar PV power is significant, and from the foregoing, it would be reasonable to use a high degradation rate of 1.5% and a low degradation rate of 0.5%.

Therefore, it is recommended that the following annual degradation rates be used in the GenCost 2023-24 LCOE calculations for large-scale solar PV:

a. High degradation rate = 1.5%.
b. Average degradation rate = 1.0%.
c. Low degradation rate = 0.5%.

6 Overall Discussion

6.1 Introduction

A detailed discussion of the following parameters used in the LCOE calculations for coal, onshore wind and large-scale solar PV are discussed in detail in the previous sections of this report:

a. Economic life (or design life).
b. Capacity factor.
c. Output degradation.

Therefore, these parameters do not need to be discussed here. However, a discussion of other relevant parameters is presented below.

6.2 Capital Cost & Fuel Costs for Coal

6.2.1 Discussion of Capital Cost of Coal

As stated earlier, it appears that the capital cost of $5,722/kW Apx Table B.9 of GenCost 2023-24 is based on a relatively expensive advanced ultra-supercritical (AUSC) power station, because using this cost rate would result in a cost of approximately $4B for a 700 MW power station, Additionally, Table 4-28 of Aurecon (2023) presents a relative cost of $4,680/kw for a 700 MW AUSC power station with a total cost of approximately $3.14B. Therefore, the GenCost 2023-24 capital cost is 122% of the Aurecon (2023) cost.

As a sensibility check, Kogan Creek in Queensland is a 750 MW supercritical (SC) power station that was commissioned in 2007 at a cost of $1.2B, which would be approximately $1.8B for the present-day cost. Consequently, the present-day capital cost of Kogan Creek would be approximately $2,400/kW. Therefore, the GenCost 2023-24 capital cost is 238% of the present-day cost for Kogan Creek.

The above discussion of capital costs is summarised in Table 6.1.

Source	Plant Type	Capital Cost ($/kW)	Ratio (GenCost 2023-24/Source)
GenCost 2023-24	AUSC	5,722	100%
Aurecon (2023)	AUSC	4,680	122%
Kogan Creek, QLD	SC	2,400	238%

Table 6.1: Comparison of Capital Costs for Black Coal
Note: *Kogan Creek capital cost has been updated to the present-day cost.*

6.2.2 Discussion of Fuel Costs for Coal

Apx Table B.9 of GenCost 2023-24 presents a high price of $11.3/GJ and a low fuel price for coal of $4.3/GJ, but GenCost 2023-24 does not explain the assumptions from which these costs are derived.

Furthermore, as a comparison, AEMO (2023) has a cost of $1.57/GJ for Kogan Creek, and it presents the following costs for other black coal generators in the NEM for 2023-24:

a. High cost = $4.47/GJ.
b. Average cost = $2.95/GJ.
c. Low cost = $1.43/GJ.

It is evident from the above that the GenCost 2023-24 fuel costs for coal are significantly higher than those presented in AEMO (2023), namely, 253% for the high fuel cost and 300% for the low fuel cost.

The discussion of the above fuel costs is summarised in Table 6.2.

Source	High Cost	Low Cost
GenCost 2023-24	$11.3/GJ	$4.30/GJ
AEMO (2023)	$4.47/GJ	$1.43/GJ
Ratio (GenCost 2023-24/AEMO)	253%	300%

Table 6.2: Comparison of Fuel Costs for Black Coal

6.2.3 Conclusions & Recommendations from Capital Cost & Fuel Costs for Coal

It is evident from the foregoing that capital cost for coal in GenCost 2023-24 is too high by a significant margin and it is recommended that they be amended as follows:

a. Reduced from $5,722/kW to $4,680/kW in accordance with Aurecon (2023) if an advanced ultra-supercritical power station is assumed in the GenCost 2023-24 LCOE calculations.
b. Reduced from $5,722/kW to $2,400/kW in accordance with Kogan Creek in Queensland if a supercritical power station is assumed in the GenCost 2023-24 LCOE calculations.

It is also evident that fuel costs for coal in GenCost 2023-24 are too high by a significant margin (253% for the high fuel cost and 300% for the fuel low cost). Therefore, it is recommended that they be amended by implementing one (or both) of the following actions:

a. The GenCost 2023-24 fuel costs be amended to conform with AEMO (2023), namely, a high fuel cost of $4.47/GJ and a low fuel cost of $1.43/GJ.
b. GenCost 2023-24 provide detailed calculations that explain the assumptions used in the derivation of fuel costs. Note that the calculations in the spreadsheet Aurecon 2023-24 does not provide sufficient detail to determine the fuel costs.

6.3 Capacity Factors for Coal

6.3.1 Discussion of Capacity Factors for Coal

As stated earlier, the high and low capacity factors of 89% and 59% used in Apx Table B.9 respectively are reasonable for existing for coal-fired power, but they are too low for advanced ultra-supercritical power that typically have high and low capacity factors of 95% and 80% respectively.

Indeed, Table 4-26 of Aurecon (2023) presents an effective annual capacity factor of 93% for an advanced ultra-supercritical power station.

Consequently, if GenCost 2023-24 wish to use the low capacity factor of 59% (which is typical of conventional coal power stations, then GenCost 2023-24 should also use the commensurate lower costs of conventional coal power.

6.3.2 Conclusions & Recommendations from Capacity Factors for Coal

It is evident from the above that that GenCost 2023-24 uses a low capacity of 59%, (which is typical for conventional coal-fired power) but uses the (high) cost of advanced ultra-supercritical coal power. This is inconsistent because the capacity factors should be in accordance with the technology that is being used in the cost analysis, namely: higher cost, higher capacity factors; lower cost, lower capacity factors.

Consequently, the following recommendations are made:

a. If GenCost 2023-24 wishes to use the capacity factors of 89% and 59% (which are typical for conventional coal-fired power), then the commensurate lower costs of this type of generation should be used.
b. Conversely, if GenCost 2023-24 wishes to us the high cost of advanced ultra-supercritical power, it should use the rate of $4,680/kW in accordance with Aurecon (2023). Furthermore, it should use the commensurate capacity factors of 95% and 80% that are typical of advanced ultra-supercritical power.

6.4 Cost & Type of Nuclear

6.4.1 Discussion of Cost & Type of Nuclear

IEA (2020) states that new-build nuclear has a similar LCOE to onshore wind and large-scale solar PV as shown in Figure 6.1.

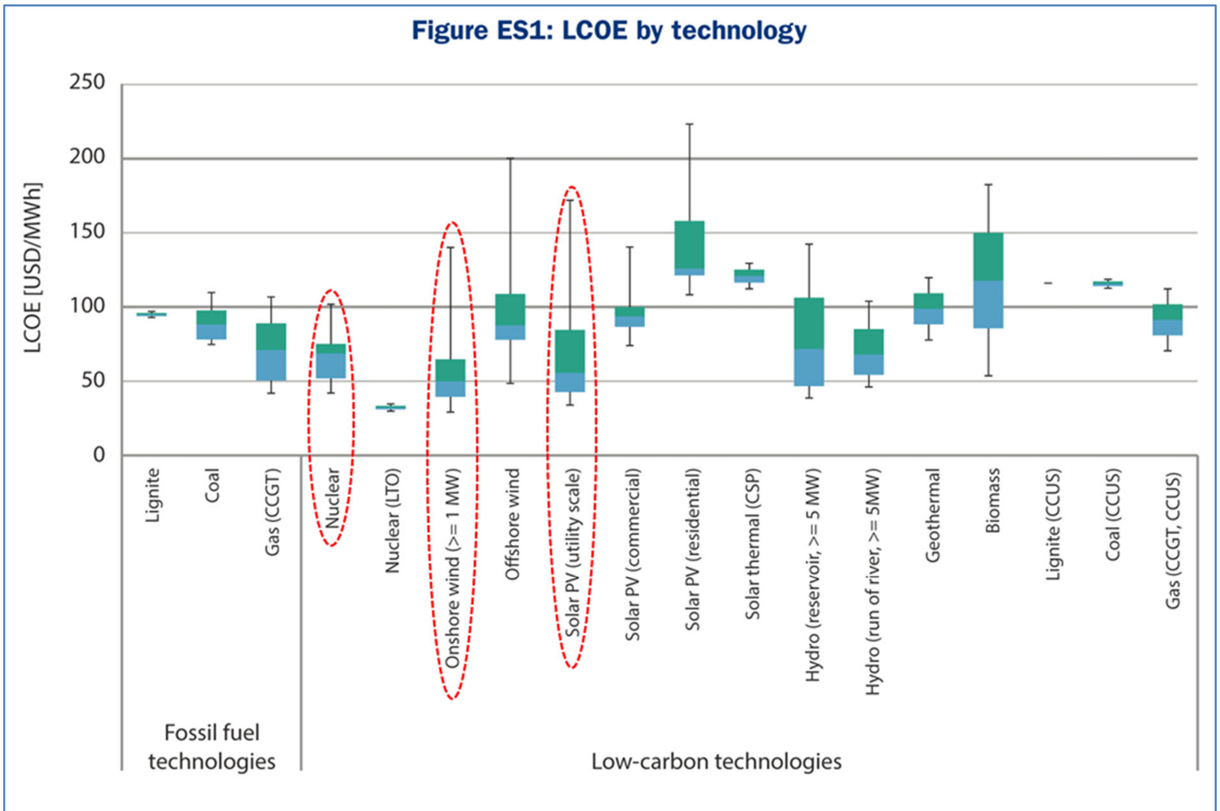
IEA (2020) also highlight that *"Electricity produced from nuclear long-term operation (LTO) by lifetime extension is highly competitive and remains not only the least cost option for low-carbon generation - when compared to building new power plants – but for all power generation across the board."* However, nuclear (LTO) is not an option for Australia because we have no nuclear power generation plants from which we could extend their LTO (long-term operation).

Furthermore, in relation to nuclear, GenCost 2023-24 only considers small modular reactor (SMR) technology, and its costs are based on a single (and now cancelled) project in Utah, USA. This has resulted in a very high LCOE estimate. However, GenCost 2023-24 does not evaluate other types of nuclear power (including SMR's) that have been deployed elsewhere. For example, in China (Reuters, 2023) and Russia (Power Technology, 2021) have deployed SMR's.

6.4.2 Conclusions & Recommendations from Cost & Type of Nuclear

It is evident from the above that GenCost 2023-24 only considered one cancelled SMR plant for its estimate of the LCOE, which has resulted in a very high cost estimate. Consequently, if GenCost 2023-24 is to consider nuclear, then it is recommended that not only the SMR technology deployed in China and Russia be considered, but also that the more diverse range of nuclear technology presented in IEA (2020) be considered.

Alternatively, it is suggested that GenCost 2023-24 delete nuclear from its LCOE calculations.



Note: Values at 7% discount rate. Box plots indicate maximum, median and minimum values. The boxes indicate the central 50% of values, i.e. the second and the third quartile.

Figure 6.1 Comparison of LCOE for Nuclear, Onshore Wind and Large-Scale Solar PV (Source: IEA, 2020)
***Note:** Red ellipses have been added to highlight new-build nuclear, onshore wind and solar PV.*

7 Conclusions & Recommendations

7.1 Conclusions

A technical assessment of the assumptions in used in GenCost 2023-24 to calculate the LCOE of black coal, onshore wind and large-scale solar PV for the following parameters is presented:

a. Economic life (or design life).
b. Capacity factor.
c. Output degradation.

In addition to the above, the costs for black coal are discussed in greater detail and the cost and type of nuclear is also discussed.

It is concluded that the GenCost 2023-24 parameters used for coal are too pessimistic and that the parameters used for onshore wind and large-scale solar PV are overly optimistic. Consequently, they should be amended, which would result in a lowering of the LCOE for coal and an increase in the LCOE for onshore wind and large-scale solar PV.

In particular, GenCost 2023-24 uses the higher cost of advanced ultra-supercritical coal, but it uses the lower capacity factors of conventional coal plants. This is inconsistent because the capacity factors should be in accordance with the technology that is being used in the cost analysis. Namely: higher cost = higher capacity factors; lower cost = lower capacity factors. Therefore, the parameters for coal should be amended to be consistent with the technology being considered in the LCOE calculation.

7.2 Recommendations

The following recommendations are made regarding the economic life , capacity factor and output degradation for black coal, onshore wind, and large-scale solar PV.

Type of Generation	Long Lifespan (years)	Average Lifespan (years)	Short Lifespan (years)
Black Coal	60	45	30
Onshore Wind	25	20	15
Large-Scale Solar PV	25	20	15

Table 7.1: Economic Lifespan for Black Coal, Onshore Wind and Large-Scale Solar PV

Type of Generation	High Capacity Factor	Average Capacity Factor	Low Capacity Factor
Black Coal	95%	87.5%	80%
Onshore Wind	44%	32%	20%
Large-Scale Solar PV	29%	23%	19%

Table 7.2: Capacity Factors for Black Coal, Onshore Wind and Large-Scale Solar PV

Type of Generation	High Output Degradation p.a.	Average Output Degradation p.a.	Low Output Degradation p.a.
Black Coal	0.097%	0.093%	0.089%
Onshore Wind	1.8%	1.6%	1.4%
Large-Scale Solar PV	1.5%	1.0%	0.5%

Table 7.3: Output Degradation for Black Coal, Onshore Wind and Large-Scale Solar PV

It is noted that GenCost 2023-24 does not consider output degradation. However, this omission leads to a significant overestimate of the power output of onshore wind and large-scale solar PV, with the consequential underestimate of the LCOE. Therefore, it is recommended that output degradation be included for all types of electricity generation in GenCost 2023-24.

It is also recommended that the capital cost of coal be reduced from $5,722/kW to either $4,680/kW in accordance with Aurecon (2023) for an advanced ultra-supercritical (AUSC) power station or $2,400/kW in accordance with Kogan Creek in Queensland for a supercritical (SC) power station. These capital costs are summarised in Table 7.4.

Source		Plant Type	Capital Cost ($/kW)	Ratio (GenCost 2023-24/Source)
GenCost 2023-24		AUSC	5,722	100%
Aurecon (2023)		AUSC	4,680	122%
Kogan Creek, QLD		SC	2,400	238%

Table 7.4: Comparison of Capital Costs for Black Coal

***Note:** Kogan Creek capital cost has been updated to the present-day cost.*

Furthermore, the GenCost 2023-24 fuel costs for black coal are 253% to 300% of those presented in AEMO (2023) as summarised in Table 7.5.

Source	High Cost	Low Cost
GenCost 2023-24	$11.3/GJ	$4.30/GJ
AEMO (2023)	$4.47/GJ	$1.43/GJ
Ratio (GenCost 2023-24/AEMO)	253%	300%

Table 7.5: Comparison of Fuel Costs for Black Coal

Consequently, it is recommended that the GenCost 2023-24 fuel costs be reduced to those presented in AEMO (2023).

Finally, regarding nuclear, only one (now cancelled) SMR plant is considered in the GenCost 2023-24 LCOE calculation, which has resulted in a very high cost estimate. Furthermore, IEA (2020) states that new-build nuclear has a similar LCOE to onshore wind and large-scale solar PV.

Therefore, it is recommended that a more diverse range of nuclear technology be presented in GenCost 2023-24. For example, refer to IEA (2020) and/or the modular reactors that have been deployed in China and Russia. Alternatively, it is recommended that nuclear be deleted.

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