Submission to the Australian Energy Regulator (AER)
Framework and Approach for the 2028-33 Transmission Revenue Determinations
Implications of Inverter-Based System Behaviour for Planning and Regulatory Outcomes

Response to AER Framework and Approach Papers for Transgrid, ElectraNet and Murraylink 2028-33 Revenue Determinations

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Submission context

This submission provides technical and policy commentary on the AER's Framework and Approach consultation for the 2028-33 transmission revenue determinations. It forms part of a broader CSPER research focus on how renewable energy benefits are shaped not only by installed capacity, but by the conditions under which energy is delivered, accessed, valued, and governed. In this submission, that perspective is applied to inverter-based resources, where simplified technical assumptions may affect planning inputs, expenditure assessment, incentive mechanisms, and regulatory outcomes under high-renewable power system conditions.

Table 1. Abbreviations and acronyms

Abbreviation	Full term
AC	Alternating Current
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
CAPEX	Capital Expenditure
CESS	Capital Expenditure Sharing Scheme
DC	Direct Current
DER	Distributed Energy Resources
DMIAM	Demand Management Innovation Allowance Mechanism
EBSS	Efficiency Benefit Sharing Scheme
ELI	Enhanced Locational Information
ISP	Integrated System Plan
LV	Low Voltage
NEM	National Electricity Market
NCC	Network Capability Component
PF	Power Factor
PV	Photovoltaic
RAB	Regulatory Asset Base
REZ	Renewable Energy Zone
RIT-T	Regulatory Investment Test for Transmission
SAM	System Advisor Model
SC	Service Component
STPIS	Service Target Performance Incentive Scheme
TNSP	Transmission Network Service Provider

1. Executive Summary

Electricity system planning and regulatory assessments in the NEM necessarily rely on simplified representations of physical assets. However, as inverter-based resources become central to generation, storage, and system operation, some simplifications can move from benign modelling choices to policy-relevant assumptions. In particular, PV inverters are often represented using fixed or averaged efficiency values within ISP-related inputs and supporting datasets, despite well-established dependence on load level, voltage, power factor, temperature, and curtailment. While these simplifications are necessary for tractability at system scale, there is growing evidence that they may introduce systematic bias when applied under realistic operating conditions, especially as inverter-based generation becomes the dominant source of supply.

To clarify how this issue relates to the AER's preliminary positions, Table 2 summarises our response to the main Framework and Approach items and identifies practical refinements that could strengthen regulatory robustness without changing the overall structure of the proposed framework.

Table 2. Summary response to AER preliminary positions

AER preliminary position	Our response	Recommended refinement
Apply STPIS version 6	Supported, but reliability incentives should increasingly recognise inverter-based operability constraints, not only outage-based performance.	Consider whether future STPIS reviews should include visibility of system strength, voltage support, and constrained-operation performance.
Apply updated CESS version 4	Supported. However, CAPEX efficiency assessment depends on planning outputs that may be affected by simplified inverter-performance assumptions.	Include condition-aware sensitivity testing for major ISP and REZ-related projects.
Apply updated Expenditure Forecast Assessment Guideline	Supported. This is a central link for this submission.	Use the guideline's modelling, benchmarking, cost-benefit, and project review tools to test key inverter-related assumptions.
Continue DMIAM	Supported. Demand management and flexibility projects should consider realistic DER participation and technical constraints.	Encourage projects that improve visibility of inverter-based and demand-side behaviour.
Forecast depreciation/opening RAB approach	No objection.	Ensure ex-post assessments consider whether realised performance differs from forecast assumptions.

Key issue

- Planning and regulatory frameworks typically assume stable and uniform inverter performance, whereas empirical and standards-based evidence shows that inverter efficiency varies with load, temperature, voltage, power factor, and curtailment conditions [1-3].
- Under non-ideal operating conditions, now increasingly common in high-renewable systems, these effects can introduce measurable deviations in energy yield and system performance, particularly at regional (e.g. REZ) scale [4, 5].
- These simplifying assumptions are embedded within planning inputs used to inform transmission investment, cost–benefit analysis, and regulatory decisions, and therefore become policy-relevant rather than purely technical abstractions.

Why this matters for AER decisions

Small deviations in inverter performance, when aggregated across large renewable fleets, can translate into material differences in estimated energy output, project valuation, and comparative assessment of transmission investments [6, 7]. If planning models systematically over- or under-estimate deliverable energy, this may affect the perceived efficiency of CAPEX and the ranking of major network investments, particularly in REZs. Current regulatory frameworks and incentive schemes are primarily designed around conventional system behaviour, and may not fully capture performance variability, operability constraints, and condition-dependent limitations associated with inverter-based resources.

As the NEM transitions toward a system with high shares of solar, storage, and inverter-based technologies, these effects are no longer marginal, they influence reliability outcomes, system utilisation, and long-term cost efficiency.

Recommendations

- Introduce condition-aware sensitivity analysis within planning and regulatory assessments to test the robustness of outcomes under realistic inverter operating conditions (e.g. temperature, curtailment, reactive power duty).
- Explicitly recognise performance variability of inverter-based resources in transmission planning and cost–benefit analysis, particularly where regional conditions differ across REZs.
- Strengthen transparency of modelling assumptions by clearly documenting where simplified representations (such as constant efficiency) are applied and where they may affect decision outcomes.
- Align regulatory incentive frameworks with emerging system characteristics, ensuring that efficiency, reliability, and performance metrics remain fit for purpose in an inverter-dominated grid.

2. Purpose and Scope

This submission responds to the AER consultation on the Framework and Approach for the 2028-33 transmission determinations. We support the AER's overall approach and recognise the importance of maintaining a clear, consistent, and credible regulatory framework as the NEM continues to transition.

The intent here is not to challenge the framework itself. Rather, the focus is on strengthening the robustness of regulatory decisions by highlighting how certain simplifying technical assumptions, particularly those related to inverter-based resources, may influence outcomes under current and emerging system conditions.

In large-scale planning exercises such as ISP, simplifications are both necessary and appropriate. For example, inverter performance is often represented using fixed or averaged efficiency values derived from standardised testing or modelling assumptions [2, 3]. However, a substantial body of empirical and standards-based evidence shows that inverter behaviour is not constant, but varies with operating conditions including load level, temperature, voltage, power factor, and curtailment [1, 4, 8, 9].

Under earlier system conditions, these simplifications had limited impact. In the current NEM context, where solar PV contributes a rapidly growing share of generation and inverter-based resources are central to future system pathways, the same assumptions can become material to system-level estimates such as energy yield, utilisation, and cost-benefit outcomes [7, 10].

This submission is particularly relevant to the AER's preliminary positions on STPIS, CESS, DMIAM, and the Expenditure Forecast Assessment Guideline, as each depends on how system performance, investment value, and efficient expenditure are assessed under changing network conditions.

In practice, expenditure assessment, incentive design, and transmission investment evaluation may draw on planning outputs, ISP-related assumptions, project-level modelling, and other technical inputs. Where these inputs rely on simplified representations of inverter-based resources, they can influence how system performance is interpreted and, in turn, how regulatory decisions are made. This is particularly relevant to the assessment of:

- the efficiency of capital and operating expenditure,
- the value and timing of network investments, and
- the effectiveness of incentive mechanisms.

If these underlying assumptions systematically over- or under-represent real system behaviour, even by small margins, the effects can flow through investment signals, regulatory assessments, and ultimately long-term cost outcomes for consumers. Accordingly, this submission aims to:

- identify where commonly used technical simplifications may introduce bias under high penetration of inverter-based resources,
- clarify how these effects relate to regulatory decisions, particularly in transmission planning and expenditure assessment, and
- suggest practical, proportionate ways to improve transparency and robustness without adding unnecessary complexity.

The observations build on recent analytical work and prior submissions relating to REZ planning and ISP processes, where similar issues have been identified in the context of regional variability, curtailment, and operating constraints.

Positioning statement: This submission focuses on how simplifying technical assumptions may affect cost efficiency, reliability, and investment outcomes in a system increasingly dominated by inverter-based resources.

3. Core Issue: Planning Assumptions vs Physical Reality

Electricity system planning in the NEM relies on simplified representations of physical assets to remain tractable at system scale. This is both necessary and standard practice. However, as inverter-based resources become the dominant source of generation, some of these simplifications are no longer neutral. Instead, they risk introducing systematic bias into planning outputs that directly inform regulatory and investment decisions.

Planning assumptions

Within current planning frameworks, including those underpinning ISP, inverter-based resources, particularly solar PV, are typically represented using constant or averaged performance parameters. In practical terms, this means that:

- inverter efficiency is treated as fixed or near-constant over time;
- performance is assumed to be stable across operating conditions; and
- regional or temporal variations in operating environments are largely abstracted into simplified inputs [2, 3, 10].

These assumptions are not incorrect in principle. They are widely used in tools such as PVWatts and SAM to support large-scale analysis. However, they implicitly assume that inverter performance is insensitive to real operating conditions, or that any deviations average out without materially affecting outcomes.

Physical reality

A substantial body of experimental, field, and standards-based evidence shows that this assumption does not hold under realistic operating conditions. In practice, inverter efficiency is condition-dependent, varying across a multidimensional operating space defined by:

- load level (partial-load vs near-rated operation),
- ambient and internal temperature,
- power factor (reactive power duty),
- DC voltage operating point, and
- curtailment or off-maximum-power-point operation [1, 3, 8, 9].

For example:

- Efficiency typically peaks at around 60-80% of rated output, and declines at lower loading levels due to proportionally higher internal losses.
- Operation at non-unity power factor (e.g. PF ≈ 0.95), increasingly required for voltage support, introduces additional resistive losses and reduces real power output [11].
- Elevated temperatures, common in several Australian regions, can trigger thermal derating, reducing available output by several percentage points above threshold conditions [12].
- Curtailment and export constraints shift inverter operation away from optimal conditions, further reducing effective efficiency [7].

These effects are individually modest, but they occur frequently and systematically in modern power systems. Importantly, they do not distribute evenly across regions. REZs, for example, experience different combinations of temperature exposure, curtailment frequency, and network constraints, leading to region-specific performance profiles.

Quantified impact

Recent analysis of inverter behaviour under Australian operating conditions indicates that the use of constant-efficiency assumptions can introduce annual AC energy bias on the order of approximately 0.06-0.13%, depending on region and operating conditions. At the scale of the NEM, where solar PV generation exceeds tens of terawatt-hours annually, even a small percentage deviation translates into tens to hundreds of gigawatt-hours of energy difference, with corresponding implications for valuation and planning outcomes. While these values may appear small in relative terms, they are material in comparative assessments, particularly where:

- projects or regions are closely ranked,
- cost-benefit differences are marginal, or
- investment decisions depend on incremental performance assumptions.

From simplification to systematic bias

The key issue is not that planning models simplify reality, this is unavoidable. The issue is that, under current system conditions, these simplifications may introduce directional and persistent bias, rather than neutral approximation. Specifically:

- Regions with higher temperatures or greater curtailment exposure may have their performance systematically overestimated relative to cooler or less constrained regions.
- System-level energy and utilisation estimates may be consistently optimistic if off-nominal operating conditions are not fully represented.
- Cost-benefit analyses and investment rankings may therefore be influenced by embedded modelling assumptions, rather than purely by underlying system value.

In this context, simplified inverter representations transition from being benign modelling choices to policy-relevant assumptions that shape regulatory and investment outcomes.

Core implication

As the NEM continues its transition toward a system dominated by inverter-based resources, maintaining alignment between planning assumptions and physical reality becomes increasingly important. Without this alignment, there is a risk that regulatory frameworks, while internally consistent, may rely on inputs that introduce systematic bias into assessments of cost efficiency, reliability, and investment value.

Therefore, this submission emphasises the need to recognise and manage this gap, not by abandoning simplification, but by ensuring that its limitations are explicit, tested, and appropriately reflected in decision-making processes. Figure 1 shows the non-linear relationship between inverter efficiency and output power, highlighting the limitations of constant-efficiency assumptions commonly used in planning models. Under nominal conditions, efficiency typically peaks at intermediate loading levels (around 60-80% of rated capacity) and declines at lower output due to proportionally higher internal losses, consistent with established performance models [1, 2]. Moreover, it shows a representative downward shift in efficiency under non-ideal conditions, such as elevated temperature or non-unity power factor operation, reflecting additional thermal and electrical losses. While the absolute differences appear modest, their systematic nature means they can accumulate across large fleets and over time. This reinforces the central point that inverter performance is condition-dependent rather than constant, and that simplified representations may introduce bias into energy yield estimates and subsequent planning outcomes.

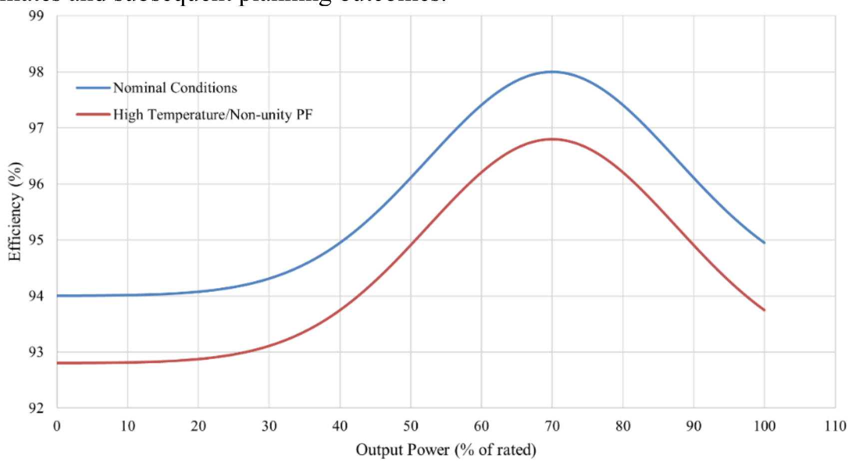

Figure 1: Representative inverter efficiency as a function of output power, illustrating deviation from constant-efficiency assumptions under realistic operating conditions.

4. Relevance to AER Preliminary Positions

Up to this point, the issue might still appear as a technical modelling nuance. It is not. Once these assumptions are embedded in planning inputs, they directly shape how the AER evaluates efficiency, risk, and value across the transmission framework. As depicted in Figure 2, simplified technical assumptions propagate through planning models into cost–benefit analysis, investment decisions, and ultimately regulatory outcomes. The key point is straightforward, but important: when such assumptions are used in planning, they do not remain technical abstractions, they become regulatory inputs. This section maps the gap between planning assumptions and physical reality directly onto the AER's decision mechanisms.

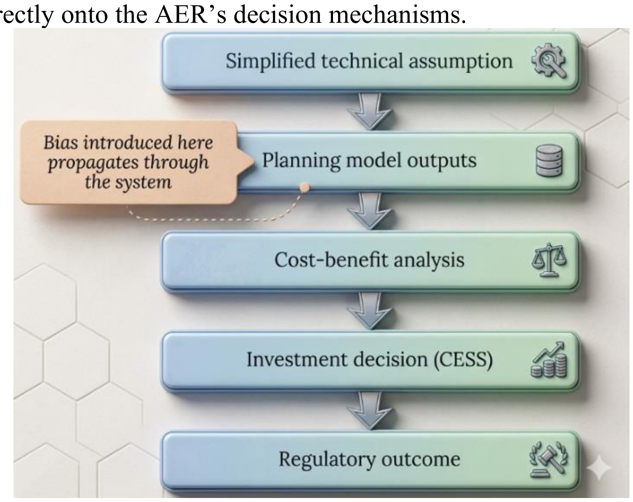

Figure 2: Pathway by which simplified technical assumptions can propagate through planning models, cost-benefit analysis, investment decisions and regulatory outcomes.

4.1 Capital Expenditure Efficiency (CESS)

Problem

The assessment of capital expenditure efficiency implicitly relies on planning outputs that assume:

- stable performance of generation assets, and
- consistent translation of installed capacity into energy and system value.

In practice, this means that project evaluation frameworks treat energy yield, utilisation, and contribution to system needs as deterministic or near-deterministic inputs.

What is missing

As outlined in Section 3, inverter-based generation does not behave in this way. Performance varies systematically with:

- temperature,
- reactive power requirements,
- curtailment exposure, and
- operating conditions across different regions.

These effects are reflected in empirical and modelling studies [1, 3, 7] but are typically simplified in planning inputs used for investment evaluation.

Implication for CESS

When these effects are not fully represented:

- expected energy output may be slightly over- or under-estimated,
- utilisation of transmission assets may be mischaracterised, and
- the apparent efficiency of capital expenditure may be distorted.

Even small deviations become important when:

- comparing closely ranked transmission projects, or
- evaluating investments across different Renewable Energy Zones (REZs), where operating conditions differ materially.

Impact

- Mis-ranking of transmission investments where performance assumptions favour certain regions or technologies
- Distortion in REZ comparisons, particularly where temperature, curtailment, or system strength conditions differ
- Potential for systematic bias in cost–benefit signals, rather than random modelling noise

4.2 Reliability Incentives (STPIS)

Problem

The STPIS is primarily designed around:

- outage frequency and duration,
- restoration performance, and
- network reliability outcomes.

These metrics reflect a system historically dominated by synchronous generation and relatively predictable asset behaviour.

What is missing

Inverter-based systems introduce new operational characteristics that are not fully captured by outage-based metrics, including:

- sensitivity to voltage and reactive power conditions,
- dependence on system strength and fault levels,
- performance variation under thermal stress and curtailment, and
- complex behaviour during disturbances and recovery events.

International and Australian system studies increasingly recognise that inverter-based resources can meet reliability requirements under normal conditions but may behave differently under stressed or non-ideal conditions [13, 14].

Implication for STPIS

The current framework may:

- capture interruptions, but
- not fully capture performance degradation or operational limitations that affect system reliability without causing outages.

Core point

In an inverter-dominated system, reliability is not only about outages. Moreover, it is about how well the system performs under constrained or stressed conditions.

Impact
- Potential under-recognition of system strength and operability risks
- Limited visibility of performance constraints that affect usable capacity
- Incentive structures that remain aligned with legacy system behaviour rather than emerging system dynamics

4.3 Expenditure Assessment and Forecasting
Problem

The AER's assessment of expenditure proposals relies on:
- forecasts of demand and generation,
- modelling of system utilisation, and
- benchmarking of efficient costs.

These processes may draw on planning datasets, ISP-related assumptions, project-level modelling, and supporting analyses [10, 15].

What is missing

Where simplified assumptions are used:
- inverter performance is treated as uniform across regions and conditions,
- DER behaviour is often aggregated and partially observable, and
- LV network conditions remain imperfectly captured in system-wide models.

This creates a situation where:
- planning models are internally consistent, but
- may not fully reflect real operating variability.

Implication for AER assessments
- Forecasts of energy, utilisation, and congestion may be systematically biased,
- Benchmarking of efficient expenditure may be influenced by assumed rather than realised performance, and
- Differences between modelled and actual system behaviour may only become visible post-investment.

Core point

If the underlying data and modelling assumptions are incomplete, then even a well-designed regulatory framework may produce biased outcomes.

Impact
- Reduced confidence in long-term forecasts used for regulatory decisions
- Risk of over- or under-estimating network needs
- Potential misalignment between planned and realised system performance

4.4 Demand-Side and System Interaction (contextual consideration)

While not the central focus of this submission, similar considerations apply on the demand side. Our related work on apartment PV and shared energy systems shows that renewable energy value is not determined by installation alone, but by whether energy can be delivered, accessed, coordinated, and fairly allocated across users. Planning frameworks increasingly assume that demand-side flexibility and DER will contribute to system efficiency and reduce network costs. In practice, these outcomes depend on the availability of enabling infrastructure, the level of participation and coordination, and network-specific conditions, which are not uniform across the system.

As a result, demand-side contributions should be interpreted with realistic assumptions regarding participation, accessibility, and distribution-level constraints when informing system utilisation and investment decisions. This is particularly relevant to initiatives supported under mechanisms such as DMIAM, where the effectiveness of demand-side solutions depends on their practical integration into real operating environments.

5. Evidence from REZ and ISP Work

The issues outlined in the previous sections are not hypothetical. They are already visible in recent planning exercises and consultation processes, particularly in REZ development and ISP analysis. This section draws on prior work to demonstrate how simplified assumptions interact with real operating conditions, and how these effects translate into planning and investment implications.

5.1 REZ-Level Evidence

Recent analysis of REZ development highlights that inverter-based generation does not perform uniformly across regions. While planning frameworks often treat similar technologies as broadly comparable, real-world operating conditions introduce meaningful variation. Evidence from REZ-focused work shows that inverter performance is influenced by a combination of:

- regional temperature profiles,
- curtailment frequency and network congestion,
- reactive power requirements for voltage support, and
- typical loading conditions over time

These factors are not evenly distributed across the system. For example:

- Regions with higher ambient temperatures are more likely to experience thermal derating, reducing effective output during peak periods [12].
- Areas with high renewable penetration and limited network capacity are more exposed to curtailment, which shifts operation away from optimal efficiency points [7].
- Locations requiring sustained voltage support may operate at non-unity power factor, increasing internal losses and reducing real power delivery [11].

While each of these effects may appear modest individually, their combined impact becomes significant when applied across large-scale renewable fleets. As shown in Figure 3, even when identical technologies are deployed across different REZs, variations in temperature, curtailment, and operating conditions can lead to measurable differences in effective energy output. This highlights that performance outcomes are not uniform across regions, and that simplified assumptions may mask underlying variability that is relevant for planning and comparative assessment.

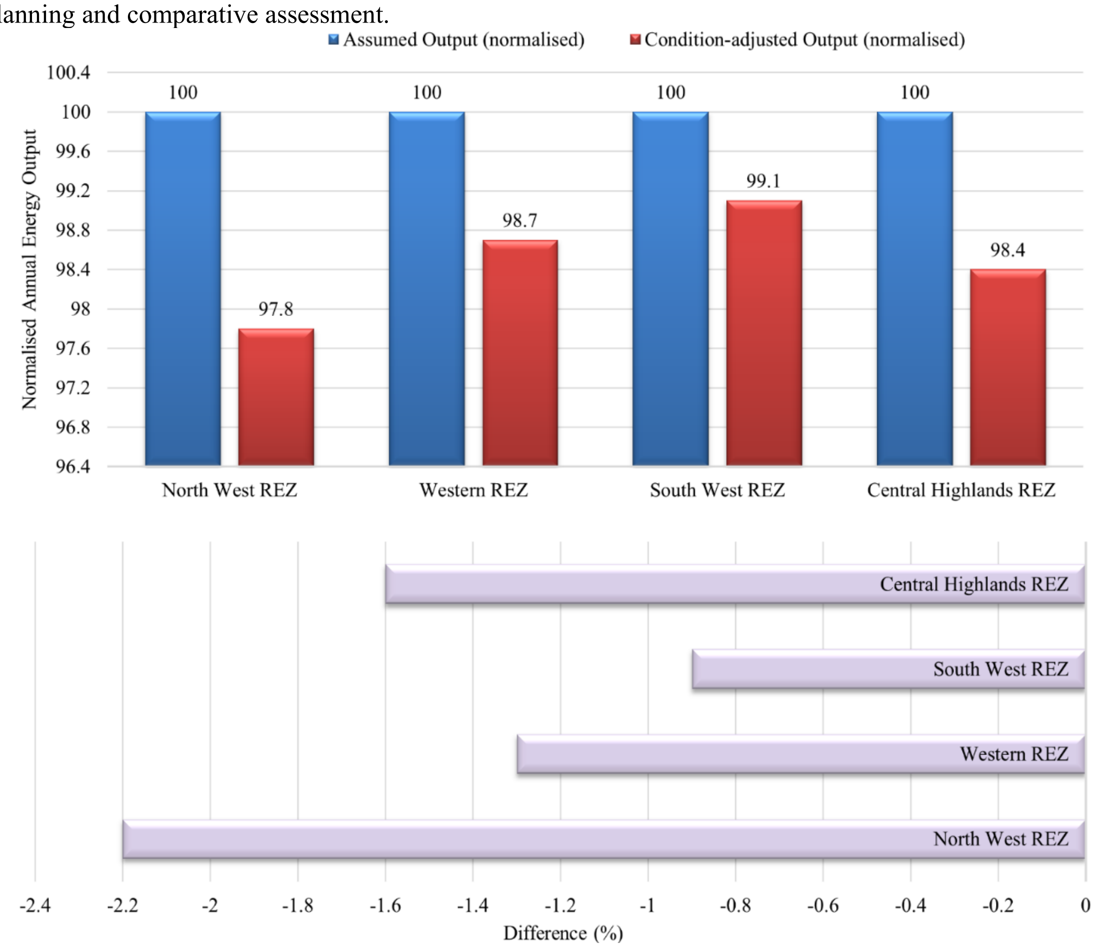

Figure 3: Normalised annual energy output across representative REZs under assumed (uniform) and condition-adjusted performance. Differences reflect the combined effects of temperature, curtailment, and operating conditions, illustrating that identical technologies do not deliver equivalent outcomes across regions.

Key message

REZs are not electrically equivalent, even when hosting similar technologies. Planning models that apply uniform performance assumptions across regions risk masking these differences. As a result:

- some zones may appear more productive than they are under real conditions,
- others may be undervalued due to conservative assumptions, and
- comparative assessments may reflect modelling simplifications rather than physical reality.

Implications for transmission planning

These effects matter directly for transmission decisions because REZs are the primary drivers of:

- network expansion,
- congestion management, and
- long-term utilisation of transmission assets.

If regional performance differences are not fully captured:

- projected energy flows may be misestimated,
- utilisation of transmission infrastructure may be over- or under-forecast, and
- investment decisions may be based on incomplete representation of system behaviour.

5.2 System-Level Planning Risks (ISP Evidence)

At the system level, similar issues emerge in the interpretation of ISP outputs and associated planning assumptions. Analysis of ISP-related material highlights several recurring risks linked to simplifying assumptions:

- the tendency to treat installed capacity as a proxy for system capability,
- reliance on idealised operability assumptions, and
- limited representation of storage and inverter performance under stressed conditions

Installed capacity versus deliverable capability

In high-renewable systems, installed megawatts do not translate directly into usable system output. Actual deliverable capability is constrained by:

- network congestion,
- system strength and voltage limits,
- storage availability and state-of-charge constraints, and
- inverter operating characteristics under non-ideal conditions.

International and Australian planning frameworks increasingly recognise that the gap between installed and deliverable capacity widens as inverter penetration increases [13, 16].

Operability assumptions

System operability depends on how generation, storage, and network assets perform under stressed conditions. However, planning models often assume:

- stable inverter response,
- sufficient system strength, and
- consistent availability of supporting services.

In practice, these conditions may not always hold simultaneously, particularly during:

- high renewable output combined with network constraints,
- extreme weather events, or
- periods of rapid system transition.

Where operability assumptions are optimistic, system performance may be overstated and required network support underestimated.

Storage and flexibility limitations

Storage plays a central role in modern planning scenarios. However, its effective contribution depends on:

- state-of-charge constraints,
- degradation and lifecycle effects, and
- operational requirements for system support.

Simplified representations may assume that storage is:

- fully available when needed, and
- able to deliver expected services without constraint.

In reality, storage availability is conditional, and its contribution to system reliability and utilisation is time- and state-dependent.

Link to transmission planning and investment decisions

Together, the REZ-level and system-level evidence points to a consistent conclusion:

Planning outputs used to inform transmission investment are sensitive to assumptions about how inverter-based resources perform under real conditions. This has several direct implications for the AER framework:

- Transmission projects may be evaluated based on expected energy flows that differ from realised outcomes.
- Cost–benefit analysis may reflect optimistic or simplified assumptions about generation and storage performance.

- Investment timing and prioritisation may be influenced by modelled system behaviour rather than fully observable constraints.

In tightly balanced systems, where investment decisions depend on marginal differences between options, even small systematic effects can influence:

- project ranking,
- perceived efficiency, and
- long-term network value.

Overall conclusion of this section

The evidence from REZ and ISP work reinforces a central point:

- Regional conditions matter.
- System behaviour is conditional.
- Simplified assumptions can propagate into planning outcomes.

When these effects are not explicitly recognised, they do not disappear. They become embedded in planning outputs and, ultimately, in regulatory and investment decisions. This does not invalidate current planning approaches, but it highlights the need to:

- interpret results with appropriate caution, and
- ensure that key assumptions are tested and transparent, particularly where they influence high-value transmission decisions.

6. Implications for Regulatory Outcomes

The issues identified in the preceding sections translate directly into regulatory risk. When simplifying technical assumptions are embedded in planning inputs, they influence how efficiency, value, and risk are assessed across the regulatory framework.

The concern is not the presence of simplification itself, but its directional effect under current system conditions. As inverter-based resources become central to generation and system operation, small and systematic deviations between assumed and actual performance can propagate into material differences in regulatory outcomes.

Biased cost-benefit analysis

Cost-benefit assessments rely on estimates of:

- energy production,
- asset utilisation, and
- system value over time.

If inverter performance is represented using simplified or constant assumptions, these estimates may be systematically biased, particularly under conditions of:

- high temperature,
- curtailment, and
- non-unity power factor operation.

Even small percentage deviations in energy yield can translate into:

- meaningful differences in revenue assumptions, and
- changes in the relative ranking of investment options.

As a result, cost–benefit analysis may reflect modelling assumptions rather than realised system performance, especially where project differences are marginal.

Inefficient capital allocation

Transmission investment decisions are based on:

- expected utilisation,
- projected flows, and
- system-wide benefits.

Where planning inputs do not fully capture condition-dependent performance:

- some assets may appear more efficient than they are in practice,
- others may be undervalued due to conservative or uniform assumptions, and
- investment prioritisation may be influenced by systematic estimation error.

This creates a risk of misallocation of capital, where resources are directed based on incomplete representation of system behaviour rather than underlying need or value.

Overestimated system capability

Planning frameworks often use installed capacity and modelled outputs as proxies for system capability. However, as demonstrated in ISP and REZ analysis:

- installed capacity does not necessarily translate into deliverable output, and
- system performance depends on operating conditions and constraints.

Where these factors are simplified or not explicitly represented:

- aggregate system capability may be overestimated,
- network utilisation may be mischaracterised, and
- the timing and scale of required investments may be affected.

This is particularly relevant in high-renewable systems, where performance variability is structural rather than exceptional.

Under-recognised reliability risks

Current reliability frameworks are largely oriented around:

- interruption metrics, and
- asset failure events.

In inverter-dominated systems, reliability is also influenced by:

- system strength and voltage conditions,
- dynamic response of inverter-based resources, and
- performance under stressed or constrained operating regimes.

Where planning assumptions do not fully reflect these factors:

- reliability risks may be under-recognised,
- system performance under stress may be overestimated, and
- incentive frameworks may not fully align with emerging system characteristics.

Overall implication

Across these areas, the same pattern emerges:

- Simplified assumptions →
- Embedded in planning models →
- Used in regulatory evaluation →
- Influence cost, investment, and reliability outcomes

If those assumptions introduce systematic bias, the resulting decisions may remain internally consistent but deviate from realised system behaviour.

The implication is not that current frameworks are incorrect, but that their effectiveness increasingly depends on:

- the transparency of underlying assumptions, and
- the extent to which those assumptions are tested against realistic operating conditions.

7. Recommendations

The objective of these recommendations is not to increase modelling complexity, but to ensure that key assumptions are visible, testable, and aligned with real system behaviour. The focus is on practical steps that can be implemented within existing processes.

Recommendation 1: Introduce condition-aware sensitivity testing

Planning and regulatory assessments should include targeted sensitivity analysis that goes beyond constant or averaged performance assumptions.

- Test outcomes under non-ideal operating conditions, including high temperature, curtailment, and non-unity power factor operation.
- Apply these sensitivities selectively to high-impact assets and regions, particularly Renewable Energy Zones (REZs).
- Use results to assess whether investment decisions remain robust under realistic operating variability.

This approach does not require replacing existing models. It adds a structured check on key assumptions where they are most likely to influence outcomes.

Recommendation 2: Explicitly recognise inverter-based performance variability

Transmission planning and evaluation processes should explicitly acknowledge that inverter-based resources do not operate with uniform performance across all conditions.

- Incorporate region-specific performance considerations in REZ and transmission assessments.
- Recognise that factors such as temperature, curtailment, and reactive power requirements can affect effective energy delivery and utilisation.
- Where full modelling is not feasible, include qualitative or semi-quantitative adjustments to reflect these effects.

This improves the realism of planning inputs without requiring detailed device-level modelling.

Recommendation 3: Strengthen linkage between modelling assumptions and incentive frameworks

Key regulatory mechanisms, including capital expenditure efficiency (CESS) and reliability incentives (STPIS), should be interpreted in light of underlying modelling assumptions.

- Ensure that performance and efficiency assessments consider how assumptions affect estimated outcomes, not just observed results.
- Where planning assumptions materially influence cost or reliability estimates, reflect this in regulatory interpretation and benchmarking.
- Consider whether existing incentive structures remain fully aligned with inverter-dominated system behaviour, particularly in relation to system strength and operability.

The aim is to ensure that incentives continue to reflect real system performance, not just modelled expectations.

Recommendation 4: Improve transparency of planning assumptions

Planning inputs used in regulatory assessments should clearly document where simplified inverter assumptions are applied, the sources of efficiency characterisation data, and the operating conditions under which those assumptions remain valid.

- Identify key assumptions, such as constant efficiency or uniform performance, and clearly define their scope and limitations.
- Highlight where these assumptions may introduce regional or system-level bias, particularly in comparative assessments across REZs or project options.
- Provide clear guidance on how results should be interpreted in light of these limitations.
- Where relevant, disclose key inverter-related assumptions, including inverter loading ratio, power factor duty, voltage range, thermal derating treatment, curtailment assumptions, and whether fixed or condition-aware efficiency values are used.

Improved transparency supports more informed decision-making and reduces the risk of unintended bias in regulatory outcomes.

Overall intent

These recommendations are designed to be proportionate and implementable. They do not require fundamental changes to existing frameworks. Instead, they focus on:

- making assumptions explicit,
- testing their impact where it matters most, and
- ensuring alignment between planning inputs and regulatory outcomes.

As the system evolves, maintaining this alignment will be critical to ensuring that investment decisions, efficiency assessments, and reliability outcomes remain robust, credible, and fit for purpose.

8. Closing Statement

We appreciate the opportunity to contribute to the AER's consultation on the Framework and Approach for the 2028-33 transmission determinations. The proposed framework provides a strong foundation for supporting efficient investment and reliable system operation during a period of significant transition in the National Electricity Market.

- The observations presented in this submission are intended to support this process by highlighting areas where closer alignment between planning assumptions and real system behaviour may further strengthen regulatory outcomes.
- We would welcome the opportunity to engage further with the AER on these issues, including providing additional technical input or clarification where helpful.

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