AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Project Energy Connect Implementation – Directions Paper

November 2023

Project Energy Connect Market Integration - Settlements Residue Consultation

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Executive summary

The implementation of Project Energy Connect (PEC) presents new challenges for the market integration into the NEM with the creation of the physical transmission loop between adjacent regions. At completion the project will provide approximately 800 MW of transmission capacity between New South Wales and South Australia power networks, delivered over two phases. The issues discussed in this paper relate to the full development of PEC, known as PEC Stage 2.

AEMO has published this Directions Paper for stakeholder consultation on the market integration of PEC and the treatment of negative interregional settlement residues (IRSR).

Key considerations

Modelling the settlement effects of PEC – AEMO engaged ACIL Allen to model the effect of PEC and the loop equality constraint in dispatch.

- Modelling results demonstrated the common occurrence of negative IRSR driven by transmission loop flows.
- Findings showed the most common settlement outcome around the loop is aggregate settlements in surplus around the loop, but with a subset of interconnectors accruing negative IRSR.

Management of negative settlement residues – It is not technically feasible nor economically efficient to maintain current practices of clamping negative IRSR in dispatch for all occurrences of negative IRSR above the threshold.

- Negative Residue Management (NRM) should only be applied where aggregate settlement around the loop is in deficit (‘net negative').
- This change to the NRM arrangements would require AEMO to update Dispatch Procedure (SO_OP_3705)[1], as a change to AEMO’s policy for managing negative IRSR.

Reallocation of negative IRSR – Where settlement in aggregate is positive around the loop but negative IRSR is accruing, AEMO has proposed approaches for the reallocation of negative IRSR around the loop.

- The reallocation of negative IRSR seeks to reasonably align the costs for negative IRSR with the transmission loop flows, acknowledging that in part, the negative IRSR is allowing for the increased value of positive IRSR in adjacent regions.
- AEMO is working under the assumption that changes to the distribution of negative IRSR would require a rule change for amendments to NER 3.6.5(a).

Payment for negative IRSR – After the reallocation of negative IRSR, consideration is required of whether negative IRSR should be charged directly to consumers in the importing region[2] or whether it should first be deducted from unit holders by reducing the payout of units purchased in the Settlements Residue Auction (SRA).

- This decision comes down to whether the deduction of negative IRSR will diminish units’ utility for trading across multiple regions and reduce interregional trading by participants.

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[1] AEMO, Dispatch Procedure SO_OP_3705: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/power_system_ops/procedures/so_op_3705-dispatch.pdf.

[2] As is the current practice.

- AEMO's preliminary position is that reallocated negative IRSR should not be deducted from unit holders, via a reduction in positive IRSR. This aligns with regulatory precedent and would limit the impact on SRA processes and units.
- NER amendments would be required to deduct payment of reallocated negative IRSR from distributions of IRSR. No NER change would be required to recover reallocated negative IRSR directly from customers, however the amendments noted above would still be required for reallocation.

Treatment of impacted SRA units – While this review is underway, AEMO has engaged with the Settlements Residue Committee (SRC) to consider the treatment of potentially impacted units on VIC-NSW and SA-VIC.

Dispatch regional boundaries – AEMO intends to implement PEC into dispatch as a separate line linking NSW and SA. The alternative micro-slice option considered would not be a proper representation of the network nor avoid issues associated with negative IRSR.

1 Purpose

AEMO has published this Directions Paper for stakeholder consultation on the proposed approaches for the management and reallocation of negative settlement residues arising from the implementation from Project Energy Connect (PEC).

1.1 Background to this Directions Paper

In November 2022, AEMO published the initial Project Energy Connect Market Integration Paper (Paper), [3] that introduced to stakeholders the market integration issues that arise from the transmission loop between VIC, SA and NSW. The Paper also considered the market and settlement impacts of PEC that give rise to transmission loop flows and negative interregional settlement residues (IRSR). This consultation received 11 written submissions from stakeholders; the submissions requested more information on the occurrence of negative IRSR and the development of options for reallocation.

In May 2023, AEMO published the PEC Implementation Update on Market Integration (Update Paper)[4] detailing AEMO's proposed approaches to integrating PEC into dispatch and market settlement residue activities. The Update Paper discussed the need for AEMO to consider the appropriateness of the way loop flow negative settlement residue is managed and allocated. AEMO also published GHD's Technical Report on conduct power system studies to assess the impact of the integration PEC in Phase 1 under various dispatch scenarios. [5]

1.2 Stakeholder consultation process

AEMO engaged ACIL Allen to model the settlement and market effect of PEC into dispatch. The results of this modelling are discussed in this Directions Paper.

The purpose of this Directions Paper is to:

- Discuss the occurrence of transmission loop negative IRSRs relative to the current network topology and dispatch and settlements processes resulting from PEC; and
- Publish and discuss ACIL Allen's modelling on the settlement effects of PEC.

AEMO is seeking feedback from stakeholders on the:

- Proposed approaches for the management and reallocation of transmission loop negative IRSR; and
- Resulting impacts on the Settlement Residue Auction (SRA).

[3] AEMO, Project Energy Connect Market Integration Paper, published 15 November 2022: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/pec-market-integration-paper/pec-market-integration-paper.pdf?la=en.

[4] AEMO Project Energy Connect Implementation Update, published 18 May 2023: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/pec-market-integration-paper/pec-implementation--update-on-market-integration-may.pdf?la=en.

[5] GHD, Project Energy Connect, Steady State Market Integration Studies, published 29 May 2023: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/pec-market-integration-paper/technical-report---phase-1-project-energy-connect-integration.pdf?la=en.

AEMO welcomes stakeholder feedback and responses to the consultation questions in this Directions Paper. A template with the consultation questions is provided. Written submissions are requested to NEMReform@aemo.com.au by 1 December 2023.

Prior to the due date for submissions, stakeholder can request a meeting with AEMO to discuss any of the recommendations or consultation questions via NEMReform@aemo.com.au.

Following stakeholder feedback, AEMO intends to finalise recommendations for the approach to managing negative IRSR and initiate relevant rule and procedure change processes as required.

AEMO's indicative timeline for this consultation is as follows:

Deliverable	Indicative Timeline
AEMO Directions Paper Consultation	
Engagement through Settlement Residue Committee (SRC) meeting	1 September 2023
Directions Paper published	November 2023
Engagement through Settlement Residue Committee (SRC) meeting	3 November 2023
Industry briefing	14 November 2023
Project Energy Connection (PEC) Industry Quarterly meeting	23 November 2023
Submissions due on Directions Paper	1 December 2023
Final Decision from Directions Paper published	December 2023
AEMC Rule Change Proposal	
AEMC rule change process	Q1 2024 – Q4 2024
AEMO Procedure and system change processes	
AEMO procedure consultations – related to negative residue management and allocation of settlements residues	Q3 2024 – Q2 2025
AEMO system updates – settlements and negative residue management	Q1 2025 – Q4 2025
PEC Implementation / capacity release	
PEC Phase 2 Testing	Q1 2025 – Q2 2026
PEC Phase 2 sufficient capacity to impact negative IRSR	Q1 2026

2 Relevant background

This section provides background on interregional settlements residues, the existing implementation of PEC, including the work undertaken to date to consider the implications on dispatch and negative settlement residue outcomes.

2.1 Dispatch, settlement residues and counter price flows

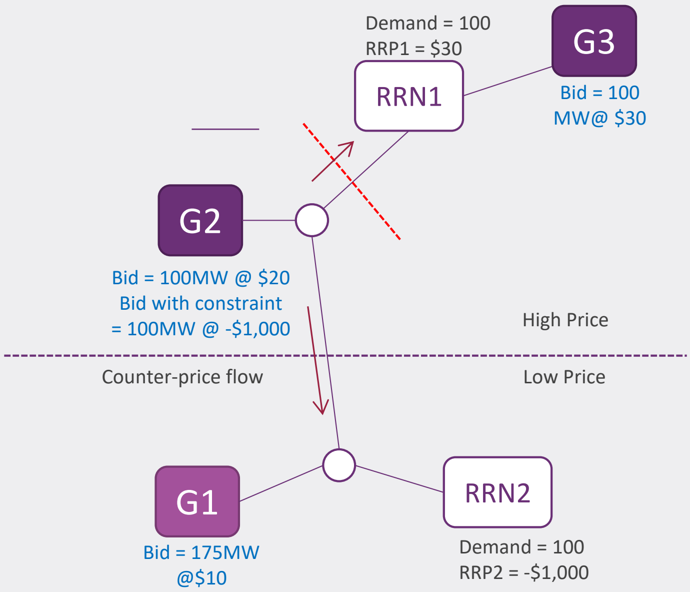
Interregional settlement residues (IRSR) occur where the regional reference prices (RRPs) between adjacent regions have diverged to reflect the cost of congestion.[6] Electricity flows in the NEM are limited by the capacity of network and interconnection. In an unconstrainted system, with unlimited interconnector capacity, generation may be dispatched to supply across regions at lowest economic cost with the marginal cost to meet demand setting the RRP across regions. Constraints and physical limitations of the power system cause congestion on the network and prices to diverge between regions.

Positive IRSR that occurs where power travels from a low to a high-priced region and is calculated as the difference between the RRPs in the importing and exporting region, multiplied by the interconnector flow. Negative IRSR occurs where power travels counter-priced, importing electricity to lower priced regions.

Under current NEM topology, negative IRSR can occur due to dispatch process and operational requirements. A generator in one region may be cheaper than importing from another, and therefore negative IRSR can be part of efficient dispatch. However, counter-priced flows can also result from generator 'mispricing' or bidding behaviour in the presence of intra-regional constraints. NEMDE is required to dispatch sufficient generation to meet demand at lowest cost within the limits of constraints, with demand and the marginal price set at each regional reference node (RRN). Dispatching lowest cost generation during periods of intra-regional constraints, can result in counter-priced flows as not all power dispatched within a region can reach the RRN. The local price at each generator transmission point within the region is different to the calculated RRP. This reflects the cost of the constraint at the transmission point. As the NEM is settled on the RRP but dispatched using local prices, generators are incentivised to bid lower than their unit's marginal cost to try to ensure they are dispatched to receive the higher RRP.

[6] Prices can also diverge as a result of interconnector losses. Interconnector losses are not the primary driver of IRSRs and are not explicitly included for the discussion in this report

The occurrence of counter priced flows and negative IRSR due to generating bidding behaviour under the NEM's RRP pricing model is further explained in Figure XX below. G1 has the lowest priced offer which is price setting RRP2. The intra-regional constraint between G2 and RRN1 means that not all power generated at G2 can supply the demand at RRN1.



- The divergence in price between RRN1 and RRN2 represents the marginal value of constraint between adjacent regions at -$20.
- The local price (LP) of G2 is calculated as the RRP plus the marginal value of the constraint multiplied by the coefficient G2 (in this instance $10). LP at G2 = $30 + (1 x -$20) = $10.
- Rather than bid at cost ($20), G2 bids below the LP ($10) at -$1,000 in order to be fully dispatched and receive the RRP set by G3. This causes counter-priced flow of 50MW and negative IRSR outcomes as follows:
  - If the constraint limit is 50MW:
    - Region 1 settlements: -$1,500
      - Customers = 100 MW demand x $30 (RRP) = $3,000
      - Generators = [50MW (G3) + 100MW (G2)] x $30 (RRP) = $4,500
    - Region 2 settlements: $500
      - Customers = 100 MW demand x $10 (RRP) = $1,000
      - Generators = 50 MW (G1) x $10 (RRP) = $500
    - IRSR = (RRP1 – RRP2) x 50MW = -$1,000

The negative residues that arise from counter-priced flows are notionally allocated to the TNSP in the importing region for cost recovery. This results in customers in the importing regions, which is the lower priced region paying for the value of residues occurring. This allocation to customers in importing regions, aligns the costs for negative IRSR with customers who are realising the benefits of the counter-priced flow.

Counter-priced flows may represent the most practicable and economically economic outcome possible for that period given the power system constraints and within the NEM's regional pricing model. However, the negative residues that arise are additional costs on market directly to the TNSPs, creating cash flow issues for TNSPs and impacting the financial operation of the market. When counter priced flows occur in the NEM, AEMO manages their impact through automated real time negative residue management (NRM) in dispatch. If the accumulated value of negative IRSR is forecast to reach negative $100,000 AEMO applies a negative residue management constraint or 'clamp' to prevent further accumulation of counter-priced flows and limit the costs of negative residues to the market. The clamp is applied in dispatch to limit counter-priced flows but does not guarantee no negative residues, as negative IRSRs are an output from the dispatch process rather than an input variable that can be directly constrained. Further, NRM constraint equations are only applied if they do not impact power system security. The use of the $100,000 constraint threshold was introduced to balance the cost and risk of negative IRSR accrual with the inefficiency of continued application of NRM constraints.

2.2 Interregional settlement residues and auctions

Accumulated IRSRs are distributed as payments or allocated for payments as part of the settlement of the market The principles for the allocation, distribution, and recovery of IRSR are set out in NER 3.6.5. AEMO provides details the methodology and process used by AEMO to allocate settlement residue in accordance with the rules in the *Methodology for the allocation and distribution of settlements residues*[7]**.** This document sets out the process for allocation of both interregional settlement residues and intra-regional settlements residues. Intra-regional settlements residues arise from the transmission losses within a region, where electricity is transferred between generation or load to the RRN and multiplied by the Marginal Loss Factors (MLFs) at each connection point. Positive and negative intra-regional settlement residues are allocated to the importing TNSP.

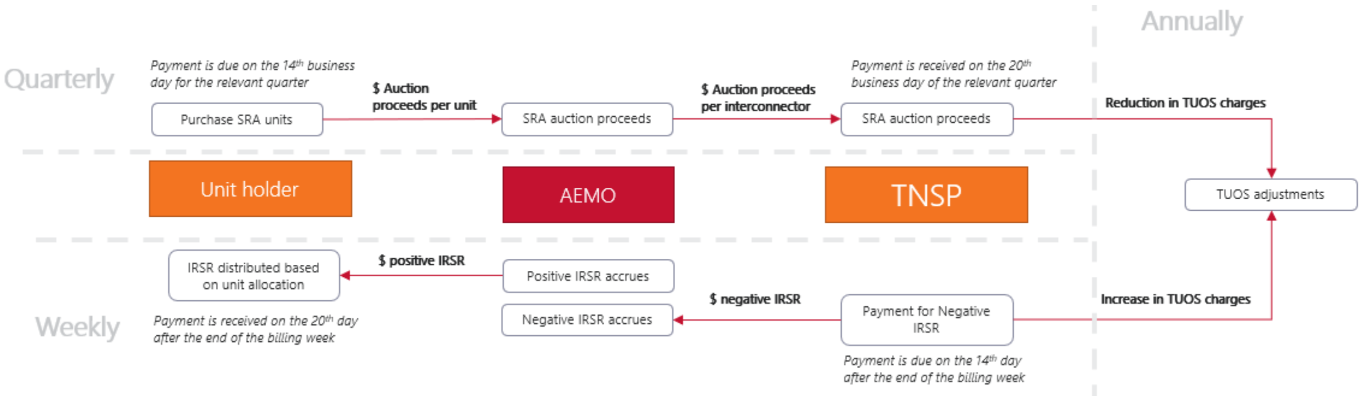
Positive interregional settlement residues in the NEM (as described in Section 2.1 above) are allocated to each directional interconnector and distributed as part of the Settlement Residue Auction (SRA) process. Traders or market participants may participate in the SRA to purchase SRA units as an entitlement to receive to a share of the accumulated positive IRSR for each directional interconnector and each relevant quarter. Unit holders may also sell back their purchased units before the relevant quarter via the Secondary Trading mechanism. The SRA process was introduced to provide market participants with a mechanism to hedge interregional price risk and promote interregional trade and competition in contracts markets. Further detail and discussion on the SRA design and impacts in included in Section 7.

SRA unit holders pay the auction price for units and receive relative distributions of positive IRSR based on their share on units for the relevant quarter specific to each directional interconnector. TNSPs for each directional interconnector receive SRA auction proceeds paid by unit holders. TNSPs pass through auction proceeds to customers in the form of lower TUOS charges for prescribed services. Negative IRSR are also allocated to and recovered directly from the TNSP in the importing region. Negative settlement IRSR is likewise passed through to consumers via adjustments to TUOS charges.

[7] AEMO, Methodology for the allocation and distribution of settlements residue: https://aemo.com.au/-/media/files/electricity/nem/settlements_and_payments/settlements/methodology_for_the_allocation_and_distribution_of_settlements_residue_july_14.pdf.

Figure 1 below illustrates the allocation and distribution of IRSR and SRA cash flows and processes. The distribution of IRSR is based on AEMO's weekly settlement cycle. While SRA units are purchased in auctions quarterly, up to three years prior to the relevant quarter, payment from unit holders for their purchased SRA units is due for the entire quarter on the 14th business day of after the start of the relevant quarter. Auction proceeds are therefore received from unit holders and distributed to TNSPs quarterly. Adjustments based on auction proceeds and negative IRSR are applied annually through adjustment in TUOS charges within the annual pricing methodology.[8]

Figure 1 Distribution of IRSR and SRA cash flows



SRA units are purchased at quarterly auctions with the clearing price set at the intersection between the bid and offer curve. Participants who wish to cancel their units after purchase offer units back into the SRA process via the secondary trading mechanism. Before offering units back into the processes for secondary trading, participants are required to provide a cash security to AEMO to offer.

While the SRA and the distribution of portions of IRSR to unit holders seeks to allow participants access to payments that reflect the interregional price differences, bidding in SRA markets is financially speculative and carries several risks, the most notable risk is that flows vary, whereas units are auctioned at a static interconnector capacity, which means a unit holder with only one unit would only receive half the price difference in revenue if the constrained flow of the interconnector was half of the capacity. Further, the effects on SRA proceeds of marginal losses are important, because marginal losses on the interconnector also vary by loading of the interconnector, the relative and absolute prices in each region, and these factors also affect relative payments, per unit, to SRA traders. Auction proceeds and participant bidding prices typically reflect how unit holders may assess interregional price dynamics for the relevant quarter as well as the perceived firmness of SRA units. This is considered in the hedge products participants may sell on the basis of SRA units.

As shown in Figures 2 and 3 below, the distributions of IRSR relative to the SRA proceeds ('payout ratio') in 2022 varied but was most commonly above 200%. IRSR distributions were most significant for SRA units exporting from VIC to SA and NSW, reflecting higher spot prices in importing regions as well as periods of regional price volatility and large price differences between the two regions. Increased payout ratios for exports from Victoria reflect a larger average price difference between VIC and SA and VIC and NSW.

[8] TNSPs are required to forecast receive received or payable for settlement residues as part of their Maximum Allowable Revenue (MAR) determination.

Figure 2 Quarterly IRSR distributions and SRA proceeds - 2022 SAVIC and VICSA

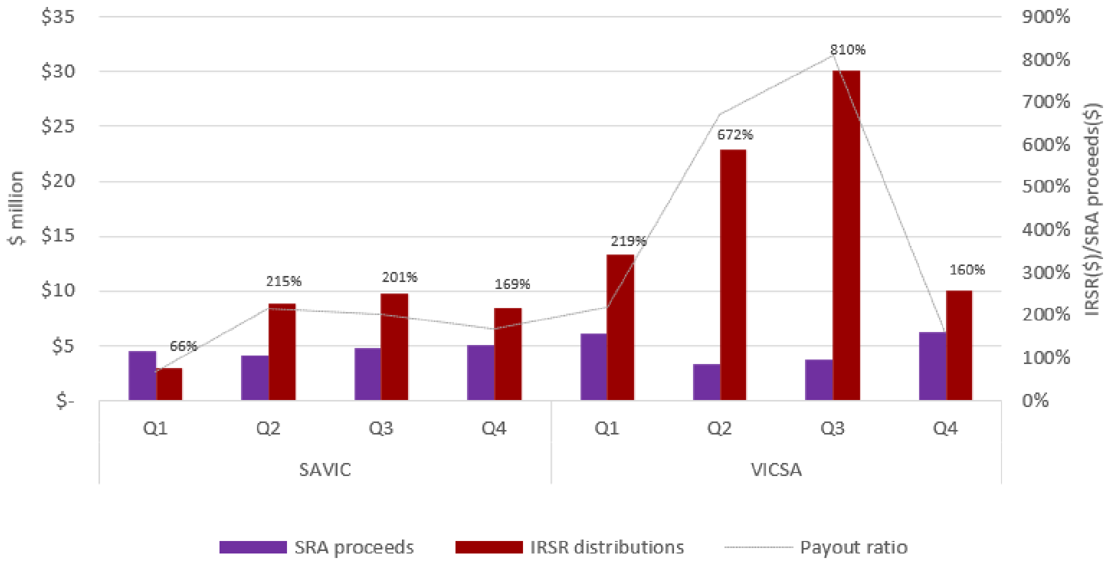
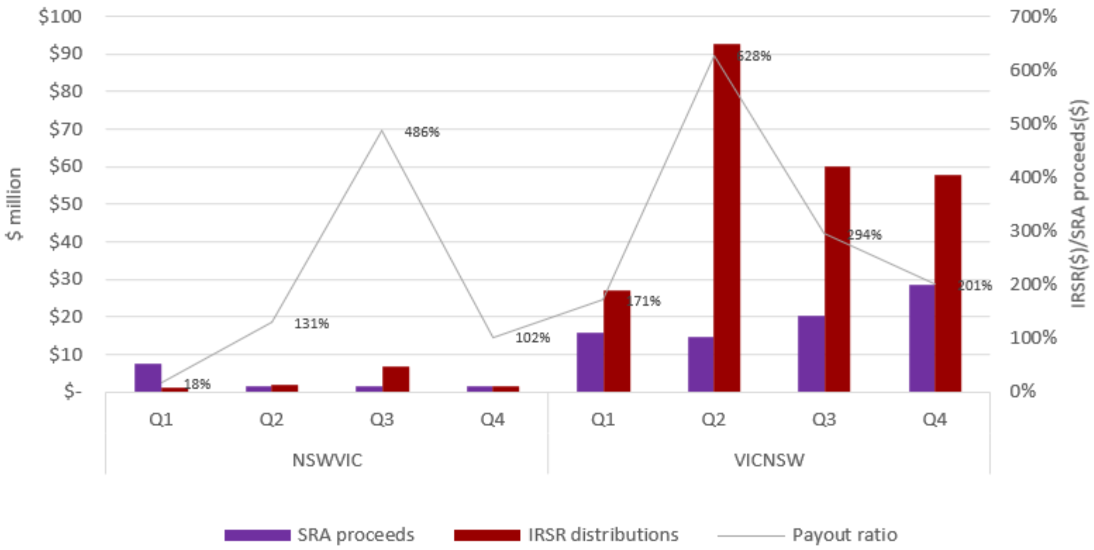


Figure 3 Quarterly IRSR distributions and SRA proceeds - 2022 VICNSW and NSWVIC



2.3 Current levels of negative interregional settlement residues

The magnitude and frequency of negative interregional settlement residues in the NEM today is reflective of the current drivers for negative IRSR including intra-regional constraints, generator bidding and dispatch.

AEMO publishes a real time estimate of negative residues within market data in EMMS under the DISPATCH.NEGATIVE_RESIDUE table[9]. Quarterly SRA auction reports publish final auction results and IRSR payments for each quarter. Table 1 below shows the cost of negative settlement residues in 2021 and 2022.

[9] AEMO, NEMWEB, Dispatch Negative Residue: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/data-nem/market-data-nemweb.

Negative IRSR typically represent less than 5% of the value of all IRSR allocated directional interconnectors on directional interconnectors in VIC, NSW and SA.

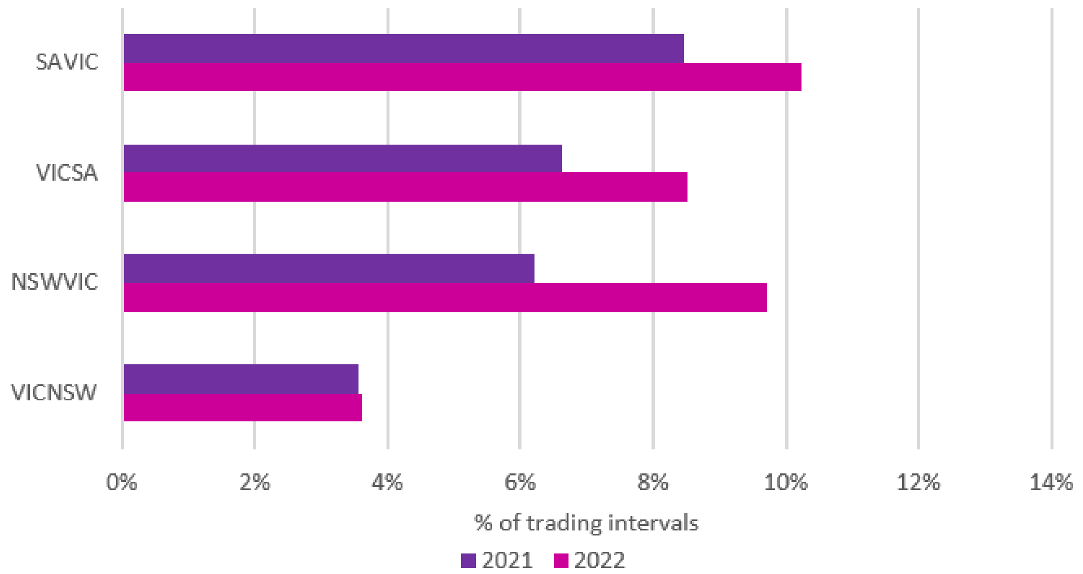
Table 1 Yearly negative IRSR – percentage of total IRSR

	Cal 2021	Cal 2022	Region paying for negative IRSR
SAVIC	$0.26M (2%)	$2.39M (7%)	VIC
VICSA	$1.00M (2%)	$2.61M (3%)	SA
NSWVIC	$0.66M (13%)	$8.25M (41%)	VIC
VICNSW	$1.50M (1%)	$2.60M (1%)	NSW

There was a significant increase in negative residues on southward negative settlement residues (NSWVIC) in 2022 to 41% of all residues allocated. This was largely driven by $6.5M of negative IRSR in Q4 2022, compared to $1.7M in positive residues. VNI was more frequently constrained due to the N^^N_NIL_3 voltage stability constraint limiting export flow. The increase in solar farms in Southwest NSW increased the invocation of this NIL_3 constraint to protect power system stability in NSW from carrying the output of solar farms in that area with additional flows from VIC. To securely accommodate SW NSW solar farms, flow was then forced counter-priced to VIC.

This is further shown in Figure 4, highlighting the percentage of trading intervals (TIs) where counter-price flow occurred on each directional interconnector. Although increasing in 2022, counter-price flow is significantly in the minority, occurring in less than 10% of trading intervals. While there is an increase in the frequency of counter-priced flow for NSWVIC in 2022, this is not as substantial as the increase in value of negative IRSR accrued (Table 1). This demonstrates the effect of the price differential between VIC and NSW during periods of southward negative flows, with intra-regional constraints and generator bidding increasing price separation between regions and price volatility in NSW.

Figure 4 Frequency of counter-priced flows – annual percentage of trading intervals



The activation of negative residue management constraints provides further insight into the price separation between regions and the drivers of large negative IRSR. For example, in 2022, for TIs where counter-priced flow was occurring on NSWVIC, NRM constraints were applied 14% of the time, compared to 8% of counter-priced TIs on SAVIC (less than 1% of all TIs). Whilst NRM constraints seek to limit the extent to which inefficient negative residues occur additional costs to consumers, the current application of NRM constraints are infrequent and primarily occur with large price differentials between adjacent regions or prolonged periods of counter-priced flow.

2.4 Regulatory framework

The allocation of IRSR and the management negative IRSRs are set out in both the NER and relevant AEMO procedures. Relevant NER clauses and AEMO procedures are detailed in Appendix 1.

Regulatory determinations have previously considered the allocation, recovery, and management of negative IRSR. While AEMO considers any decision or change to the management and allocation of negative IRSR following the implementation of PEC should have regard to previous regulatory precent where applicable, all changes must be fit-for-purpose in the transitioning power system. Specifically, the implementation of PEC will impact power flow dynamics between adjacent regions and signal a shift towards an increasingly meshed system.

Figure 5 Relevant regulatory determinations

Relevant regulatory precedents

Negative Inter-regional settlement residue Rule 2006[10] -

Shifted the allocation of net negative IRSR to TNSPs

The Negative inter-regional settlement residue Rule 2006 ('2006 Rule') shifted the recovery of net negative IRSRs from the SRA unit holders to importing TNSPs, via a reduction in auction proceeds. Prior to the 2006 Rule, negative IRSR were recovered in the first instance by netting negative residues from the positive residues accumulated within the same billing week. If the value of negative IRSR was greater than the available positive

[10] AEMC, Rule Determination – Recovery of Negative Inter-Regional Settlements Residue (2006): https://www.aemc.gov.au/sites/default/files/content/1a551528-768a-4119-8792-739de99c937d/Final-Rule-Determination.pdf.

residues, these net negative residues were treated as an auction expense and recovered from auction fees to SRA unit holders.

The 2006 Rule shifted the allocation of the net negative residues only to the auction proceeds received by the TNSPs, as it sought to limit the impact on auction fees and participation, as well as better align the timeframes for allocation of who the cost of negative residues was allocated to. When net negative IRSR was recovered from auction fees, future auction participants were essentially subsidising IRSR distributions for the relevant quarter.

The final determination acknowledged the impact of allocating net negative IRSR to TNSPs instead of unit holders. While removing the obligation on SRA unit holders may improve the trading performance of SRA units, recovery from auction proceeds introduces a level of volatility for TNSPs and limits the extent to which auction proceeds are used to reduce customer TUOS costs. However, any expected increase in IRSR to unit holders due to lower auction fees should theoretically be realised in higher auction proceeds as demand for IRSR increases bid prices.

The 2006 rule did not consider the appropriateness of the weekly deduction of negative IRSR from positive IRSR.

AEMO considers the 2006 Rule sets a precedent that intertemporal cross-subsidies between auctions (quarters) should be avoided. AEMO will seek to continue to avoid introducing any intertemporal cross-subsidies in allocation of residues to unit holders.

Congestion Management Review 2008[11]

Removed netting negative IRSR against positive IRSR, negative IRSR recovered directly from TNSPs

The Congestion Management Review in 2008 (CMR) assessed improvements to increase the firmness of SRA units and to assist participants to manage inter-regional price risk in the NEM. The CMR recommended the removal of the intra-week netting of negative IRSR against positive IRSR and instead allocated the liability to pay for negative IRSR directly to the TNSP.[12] The CMR considered the level of basis risk in the NEM and the financial instruments available for market participants to manage this risk, noting if participants cannot obtain sufficient hedge cover, they may choose to not contract across regions – which may have the negative effect of decreasing competition in contract markets.

While units are by design unfirm products the recovery of negative IRSR from positive IRSR was considered to further reduce unit firmness without significant benefit or clear distribution of negative residues to generators or customers who benefited from counter-priced flow. The CMR determined that the direct billing and recovery from importing TNSPs, recovered costs from the customer base in the region that benefited from lower prices during the negative residue period and was a more direct and transparent way of recovery. Despite acknowledging the net effect to customers as difficult to quantity, this change was supported as it prioritised unit holders retaining the full value of positive IRSR accumulated.

AEMO considers the CMR provides the regulatory precedents that negative residues should not be recovered from SRA unit holders and should be recovered from the TUoS payees in the importing region.

Review of the Management of Negative Inter-regional Settlements Residues 2014[13]

[11] AEMC, Congestion Management Review 2008: https://www.aemc.gov.au/sites/default/files/content/ed17404e-3a72-491f-a579-b92aaddace36/Final-Report.PDF.

[12] This was subsequently enacted in the NER through the Negative Settlements Rule 2009: https://www.aemc.gov.au/sites/default/files/content/ce4cbde5-0cae-43c2-9d9a-e20271451746/Final-Rule-Determination.pdf.

[13] AEMC, Management of Negative Inter-regional Settlements Residues 2014: https://www.aemc.gov.au/markets-reviews-advice/management-of-negative-inter-regional-settlements.

Confirmed the appropriateness of negative residue management via interconnector clamping

The review of the Management of Negative Inter-regional Settlements Residues 2014 (‘negative residue management review’) found AEMO’s automated process to invoke interconnector constraints to prevent further negative IRSR by reducing counter-price flow was reasonably efficient and should continue where the accumulation of negative IRSR reaches the $100,000 threshold. Negative residue management should be retained to limit the extent to which customers in the importing regions are paying for negative IRSR with no market mechanism to hedge against these negative costs. The negative residue management review also found $100,000 constraint threshold appropriately balanced limiting the costs of negative IRSR to consumers with the inefficiency of increase application of NRM constraints as a form of intervention in normal dispatch outcomes.

AEMO considers the negative residue management review provides the regulatory precedent that negative residues should be limited in an automated dispatch process to the order of $100,000.

3 Project Energy Connect overview

PEC is an electricity transmission project to deliver a physical interconnection between South Australia and New South Wales electricity networks, to be constructed jointly by Electranet and Transgrid. At completion the project will provide approximately 800 MW of transmission capacity between New South Wales and South Australia power networks, delivered over two phases:

- PEC Phase 1 (150 MW bi-directional capacity). The first phase will comprise the connection between Robertstown and Buronga. Progressive capacity release is estimated from mid-2024.
- PEC Phase 2 (combined transfer limit across Heywood and PEC interconnectors: 1,300 MW import into South Australia and 1350 MW export). The second phase comprises the connection between Buronga and Wagga Wagga. Full capacity release is currently targeted to be released by 1 July 2026.

The development of PEC will establish the first AC transmission 'loop' across regulated interconnectors in the NEM. This transmission loop will give rise to 'loop flows' as power travels across interconnectors, and between regions. Loop flows may occur where one line in a loop is impacted by an intra-regional constraint/s, and this has a flow on effect on the way other lines in the loop move power around the circuit. Electricity flows in an AC circuit are governed by Kirchhoff's law for the flow of power in parallel lines.

Project Energy Connect will be implemented into NEMDE via a mesh loop constraint ('loop flow constraint') that governs flow between all three regions and models sharing between the AC components of the interconnectors. This loop flow constraint is required to operate an equality constraint, that continuously binds in NEMDE.

3.1 Project Energy Connect Market Integration Papers

AEMO has published to date two industry Project Energy Connect Market Integration Papers discussing the integration of PEC into market system and the occurrence of loop flows, including the potential impact on negative settlement residues.

The occurrence of loop flows has the potential to give rise to the 'spring washer' pricing effect which results in inconsistent pricing variations between nodes connected in a loop. Price spikes occur downstream of the constraint to reflect the congestion cost for the delivery of additional power from the region where marginal prices are higher. This will result in counter-price flows and negative settlement residues around the loop.

In December 2022, AEMO published an initial Project Energy Connect Market Integration Paper[14] discussing the integration of PEC into dispatch and the theoretical effect of loop flows on negative settlement residues as part of normal dispatch. The paper was published as an overview and consultation paper.

AEMO received 11 written submissions in response to the PEC Market Integration Paper, with stakeholders providing feedback generally on the proposed market integration approach and NSR options provided.

Broadly stakeholders acknowledged the issue, and the likely occurrence of loop flows and resulting NSR. However, most stakeholders considered more information to consider in detail NSR reallocation options, including modelling that establishes the extent to which NSRs are likely to accrues as well as the dispatch constraints, market conditions and prices that are likely to be present during periods of counter-priced flows. Stakeholders

[14] AEMO, Project Energy Connect Market Integration, December 2022: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/pec-market-integration-paper/pec-market-integration-paper.pdf?la=en.

also questioned the role of the phase shifting transformers (PST) and how they are reflected in the dispatch process.

In May 2023, AEMO published the Project Energy Connect Implementation Update[15] ('update report') to provide an update on the market integration activities of PEC specifically relating to dispatch and settlement residues.

- Dispatch – AEMO expects the integration of PEC to significantly change power system flows by increasing transmission capacity to NSW and SA, and in doing so increase the complexity of inter-regional power flows. AEMO will reflect PEC loop flows in NEMDE via a loop flow equality constraint that will always binds in dispatch.

  Proposed PEC loop model equality constraint:

  $PEC = x_{VNI} * VNI + x_{Heywood} * Heywood + \Theta_{PST}$

  Where PEC, VNI and Heywood are southward flows i.e.:

  - x### represents the coefficient
  - PEC represents NSW to SA,VNI represents NSW to VIC, Heywood represents VIC to SA
  - The ϴ PST represents positive flows from SA to NSW

  Coefficients and ϴ PST are set out below:

Scenario	Coefficients – Analytical Estimation		
	xVNI	xHeywood	θPST
1) No outage, PST - 6.73°	0.1413	0.8084	-20.9260
2) No outage, PST 0 °	0.1410	0.8073	73.7164
3) No outage, PST 8 °	0.1408	0.8090	186.6568

  The PSTs will be integrated into dispatch on the loop flow constraint via an offset coefficient. AEMO does not expect to use dispatch for PST setpoint control. The PST setting that best reflects the position of the PST angle on the transformer during pre-dispatch will be an input into NEMDE via the loop flow constraint equation.

- Settlement residues – The integration of PEC has created a need to consider the appropriateness of the way loop flow negative IRSR is managed and allocated. Any change to the allocation of negative IRSR should be done so by demonstrating sufficient grounds to change and a robust and reasonably efficient process to allocate negative IRSR around the loop.

3.2 Dispatch regional boundaries – micro slice option

As described in the PEC Market Integration Paper[16], AEMO intends to implement PEC as a separate line linking NSW and SA for the purposes of dispatch (the 'Interconnector' model) in AEMO's dispatch model. The Paper also

[15] AEMO, Project Energy Connect – Update on Market Integration, May 2023: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/pec-market-integration-paper/pec-implementation--update-on-market-integration-may.pdf?la=en.

[16] AEMO, PEC Market Integration Paper 2022, Section 3.2: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/pec-market-integration-paper/pec-market-integration-paper.pdf?la=en.

considered integrating PEC using a 'Micro-slice' model to maintain the current topology of the NEM, and without a direct link between NSW and SA.

A Micro-slice integration would insert a small VIC region interfacing between NSW and SA allowing PEC capacity to be represented as an increase on both SA-VIC and VIC-NSW regions interconnection. This may require consideration of the definitions and boundaries of each adjacent *region*[17] and if there is possible need for a region change application under NER 2A.2.1.

AEMO considers this option not suitable for the integration of PEC as it would not be a proper representation of the physical network and would not solve the problem of increased negative residues and uncertainty associated with transmission loop flows.

NER 3.8.1 requires AEMO to operate a central dispatch process to maximise the value of spot market trading subject to the design elements and inputs in the dispatch engine including:

- 3.8.1 (b) (4) – power system security requirements
- 3.8.1 (b) (5) – network constraints
- 3.8.1 (b)(11) – management of negative settlements residue.

While the micro-slice model would maintain the current network topology for the purposes of dispatch, it would include a more significant approximation of the physical system compared to the existing approximations in NEMDE.[18] Considering the scale of PEC, AEMO considers this may risk not sufficiently allowing NEMDE to apply constraints and power system security requirements based physical network requirements and maximise the value of each transmission element.

Further, implementing PEC as an increase on SA-VIC would not remove the occurrence of loop flows but rather distribute loop flows across SA-VIC and VIC-NSW. This may AEMO's ability to maintain central dispatch with regard to a reasonably efficient approach for the management of negative settlement residues. For example, the micro-slice model would likely give rise to additional uncertainty and variability of settlement outcomes on SA-VIC as power flows on Heywood and PEC are represented as a single (two-directional) interconnector. In this example, negative residues driven by transmission loop flows would therefore be continually net off between Hey and PEC in settlement. Gross IRSR would vary significantly depending on the location and direction of counter-priced flow around the loop. This may result in inequitable distribution of negative IRSR with VIC customers increasingly paying for power flows that are maximising the value around the loop in other regions. Two examples of how the micro-slice option artificially changes power flows and IRSR between the three regions are shown in Appendix A2.

This practice is likely to cause additional issues when considering SA-VIC IRSR and SRA products as it removes the ability for accrued negative IRSR through VIC to be reallocated fully around the loop based on dispatch outcomes. AEMO considers that the use of the micro-slice option would also require an approach for the reallocation of negative IRSR between the two interconnectors, similarly to the principles and approach described in Section 6.2.

AEMO notes that while the micro-slice option retains the radial network topology of the current network model, inefficient settlement outcomes are created from this approximation that do not represent actual flows on the

[17] NER v 202, Chapter 10, *region* - An area determined by the AEMC in accordance with Chapter 2A, being an area served by a particular part of the transmission network containing one or more major load centres or generation centres or both.

[18] Interconnector approximations in NEMDE include: VNI as four physical links represented as a single interconnector, Heywood and Murray link represented as a single VIC-SA link

network. The current frameworks for the management and allocation of negative IRSR would not remain fit for purpose, and it would be increasingly difficult to value SRA units as transmission loop flows netted against IRSR decrease the firmness of hedging instruments.

Sample comparisons of the interconnector and micro-slice dispatch models are included in Appendix A2.

4 Modelling the settlement effects of Project Energy Connect

AEMO engaged ACIL Allen to undertake market modelling of the integration of the PEC loop flow constraint in NEMDE. The ACIL Allen modelling report is published on the Project Energy Connect Market Integration consultation page.[19] This section provides a summary of key modelling findings and provides additional AEMO response and context to the findings.

The objective of this modelling was to advise on the dispatch flow and settlement outcomes, including quantification of negative interregional settlement residues.

This modelling was to provide sample dispatch and settlement outcomes across the three loop directional interconnectors to assess the presence of negative interregional settlement residues. It was not the intention of the work to forecast prices and revenue outcomes, but rather demonstrate the occurrence of negative IRSR and loop flow dispatch.

To consider the scale of negative IRSR accrual, the current practice of negative residue management through interconnector clamping via constraint activation was not included in the modelling approach. This section provides a summary of key modelling findings and provides additional AEMO context to the ACIL Allen findings.

Table 2 Summary of ACIL Allen findings and AEMO response/context

No.	ACIL Finding	AEMO response/ context
	Key findings	
1	Negative IRSR may become a common part of dispatch	Expected as a part of transmission loop dynamics and efficient dispatch
2	Negative IRSR typically occur where aggregate IRSR around the loop is positive	Demonstrates the natural balancing effect of loop flow topology. Indicates the need to develop principles for the reallocation of negative IRSR around the loop.
3	Net negative IRSR around the loop occur in the minority	Implies a requirement to retain some form of negative residue management for instance of negative in aggregate
	Additional findings	

[19] ACIL Allen for AEMO, Modelling the Settlement Effects of Project Energy Connect - https://aemo.com.au/en/consultations/current-and-closed-consultations/project-energy-connect-market-integration-paper

No.	ACIL Finding	AEMO response/ context
4	Phase shifting transformers (PST) will impact settlement outcomes	The PST setting will be operated by Transgrid as an input into NEMDE. AEMO will not use NEMDE for set point control.
5	Inclusion of the loop flow constraint may impact theoretical LMP outcomes	This will not be an issue for the NEM as NEMDE is not a full network model. LMPs are calculated without the inclusion of intra-regional lines.

4.1 Key inter-regional settlements findings from ACIL Allen modelling

1. Negative inter-regional settlement residues may become a common part of dispatch.
   - Under current network topology inter-regional settlement residues can normally positive, although intra-regional constraints and generator bidding do cause counter-price flows. The modelling indicates that with the introduction of PEC, positive inter-regional settlement residues will no longer be the prevailing inter-regional settlement outcome. The results indicate that only <u>7% to 11% of the time will the loop have positive inter-regional settlement residues in aggregate, where all three interconnectors are also positive</u>.
   - The PEC loop will commonly result in negative inter-regional settlement residues on an interconnector within the loop, and this expected as a part of efficient dispatch. This is primarily driven by the inclusion of the loop flow constraint required to represent the physical flow limits of the loop and is prevalent during periods where intra-regional constraints bind, because the equality constraint in itself does not create the spring washer effect, it is only in combination with another constraint, either an intra-regional constraint or one of the interconnector limit constraints, does this occur.
2. Negative inter-regional settlement residues may typically occur where aggregate IRSR around the loop is positive.
   - With the inclusion of the loop flow equality constraint, power flows on inter-connectors and dispatch outcomes are governed by the relative coefficients. The affected balancing of flows between the three regions will commonly result in one or two inter-connectors delivering counter-priced flows to maximise the value of economic dispatch around the loop. The results indicate this may typically occur where overall IRSR around the loop is in surplus ('net positive') and one, or two directional interconnectors IRSR is negative. That is there is there is positive IRSR in aggregate, being a settlement surplus around the loop, but one or two directional interconnectors are accruing NSR for that trading interval. <u>The modelling found this to be the predominant scenario occurring approximately 40% of the time</u>.
   - This scenario where aggregate settlement surplus yet with negative RSR on a directional interconnector within the loop, demonstrate the natural balancing effect of loop network topology and the appropriateness of considering loop flow NIRSR as an acceptable dispatch outcome. This indicates a need to develop principles and approach for the reallocation of settlement residues around the loop

Modelling results - occurrence of loop flows and negative settlements residues

ACIL Allen modelling results demonstrate the normal occurrence of negative IRSR one on or two legs of the loop, where the settlement in aggregate around the loop is positive. Transmission loop flows and the relationship between the three interconnectors means that negative IRSR on one leg may allow for optimal overall dispatch and allow greater positive settlements on other legs. Modelling presents scenarios where no NRM clamping is applied to demonstrate the extent to which counter-price flows accrue and the infeasibility of maintaining real time interconnector clamping.

Percentage of trading intervals - IRSR that are positive or negative

	VNI	PEC	Heywood
Positive	42% - 66%	30% -47%	20% - 29%
Negative	3% - 10%	18% - 23%	25% - 38%

	Loop aggregate
Positive	46% - 69%
Negative	2% - 6%

The above table shows the frequency of IRSR on each interconnector and aggregate around the loop. The frequency is calculated on an hourly basis based on the cadence of modelling outputs. The modelling is lossless, and instances where there are no IRSRs (no price differences) are excluded. The occurrence of negative IRSR for each interconnector is significantly larger than the occurrence when considering the loop in aggregate or net settlement residues around the loop. When aggregate IRSR is positive around the loop, approximately 90% of occurrences will include negative IRSR on one or two interconnectors, demonstrating the balancing effect of transmission loop flows impacting negative IRSR around the loop.

	Loop aggregate
Positive	46% - 69%
Negative	2% - 6%

Positive on all interconnectors
9% - 12%

Negative on one or two interconnectors
88% - 91%

3. Negative residues in aggregate around the loop occur in the minority.

   – The modelling results indicate that aggregate negative IRSR around the loop may occur, which is when, ignoring settlement residues from marginal loss factors, settlement is in deficit. The modelling results indicated the frequency and value of settlement deficits may be small (e.g., frequency of 2%-5% of the time) and should occur where intra-regional constraints are affecting dispatch and creating counter-priced flows between two regions, with the loop flow constraint spreading the negative IRSR around the whole loop. In this scenario there may be significant price differences between regions and negative IRSR occurring on two legs of the loop. The modelling suggested these settlement deficits around the loop may increase over time as intra-regional constraints, particularly in NSW, were forecast to occur.

4.2 Additional findings

ACIL Allen provided additional analysis of the function of the loop flow constraint in dispatch in the report. This section includes a description of the ACIL modelling report additions findings and details AEMO's response given the broader context of the PEC Implementation work program.

1. Phase shifting transformers (PST) will impact settlement outcomes but do not mitigate negative IRSR.

   – Implementing the PST setting as an offset term in the loop flow constraint, will have an effect on dispatch and settlement outcomes as it changes the relative power balance around the loop. Changing the PST setting may have a lower effect on PEC and Heywood flows with higher relative loop flow constraint coefficients of 1 and 0.81 respectively, than VNI has the highest capacity and lowest coefficient on the loop flow constraints which leads to the highest range of dispatch outcomes. ACIL Allen suggested a different strategy such as optimisation (for example, through NEMDE, or pre-dispatch) may provide a more economical dispatch outcome where the PST setting is focused on maximising the value of trade.

AEMO response/ context

PSTs tap setting/ angle will be included as an input into AEMO NEM Dispatch Engine. The tap setting will be maintained in the first instance by Transgrid operations, and AEMO will not include an optimisation of tap settings into NEMDE for system integration. Taps can be manually or automatically changed to divert flows between Heywood and PEC when one of them gets closer to the limits. PSTs will operate on PEC with the intention of shifting flow the PST tap position to provide the sharing of power between PEC and Heywood interconnectors. The operation of a PST is unlikely to be able to completely change prevalence and occurrence of negative IRSR.

Further information on the operation of a PST is provided in the **Project Energy Connect System Integration Industry Update** on 17 August 2023. Transgrid presentation is found on Project Energy Connect website - https://www.projectenergyconnect.com.au/moreInformation.php?page=3

2. Inclusion of the loop flow constraint may impact theoretical LMP outcomes.

   – The modelling identified that the proposed loop flow constraint does not include the impact of intra-regional constraints and will produce inaccurate Locational Marginal Prices (LMPs) that do not include the impact of the loop flow constraint on nodal pricing. ACIL Allen suggested this may be updated through the inclusion of generator and dispatchable load terms in the loop flow constraint. Alternatively, ACIL Allen suggested correct LMPs may be calculated by including the marginal cost of the loop flow constraint in the Local Price formula as used in NEMDE. This could be done by including the coefficient of the lines in the full loop flow constraint, and the shadow price of the loop flow constraint.

AEMO response/ context

The recommendation provided in the ACIL modelling report is specific to theoretical LMP outcomes under a full network model, where all transmission lines are included in the model and dispatched alongside generators. The NEMDE dispatch model is not a full network model – instead using more generic constraints to represent the limits of network flows, with only scheduled generators, loads, and interconnectors directly dispatched.

NEMDE constraints are calculated with the market variables NEMDE can dispatch on the left-hand side (LHS). That is energy and FCAS generating units and loads, interconnectors and co-optimised regional FCAS requirements. Lines are not included on the LHS of constraints. Therefore, where LMPs are calculated in the NEM to include the impact of the marginal cost of constraints, these constraints only include generators, loads and interconnectors at those nodes on the network.

As per the existing process for constraints in NEMDE, the PEC loop flow constraint does not include the impact of intra-regional lines. As stated in the ACIL findings, this would create an approximation of system conditions and LMPs calculated under the current approach would not include the marginal cost of the loop flow constraint. While this would theoretically create difference between the Local Price from NEMDE and the correct LMP with the contribution of the loop flow constraint, this is not an issue within the current NEMDE dispatch model as all LMPs are calculated without the inclusion of the impact of intra-regional lines, as would be the case under the full network model, and most importantly, LMPs are not used for settlement. The intra-regional lines are represented in NEMDE by other generic constraints that may bind simultaneously with the loop flow constraint. With the inclusion of the loop flow constraint, generators will be dispatched based on the NEMDE LMP. If a generating unit has an offer to generate below the Local Price it will be dispatched, regardless of the theoretical LMP that would be calculated under the full network model which may be higher or lower. The approximation included in the formulation of the loop flow constraint is already a function of NEMDE design.

Further information on the formulation of constraints can be found here: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/congestion-information-resource

5 Statement of issue

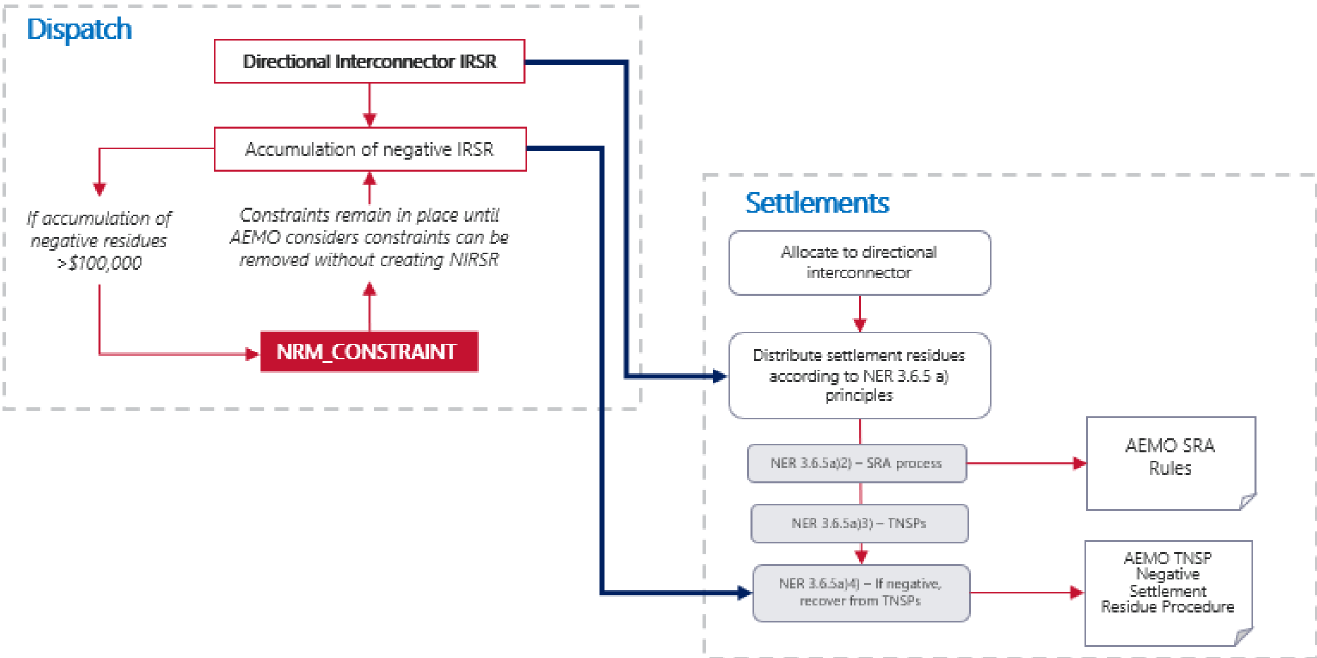
This section describes the issue with application of the current process for the management and allocation of negative IRSR within the context of the PEC transmission loop.

The current process was designed to manage negative IRSR as a limited and abnormal part of dispatch, where negative IRSRs are primarily driven by intra-regional constraints. The development of PEC will fundamentally change the incidence of negative residues as flow around the loop will be governed by the physics of transmission loops. Coefficients of the loop flow constraint govern the targets for interconnector limits and the sharing of flow around the loop. The occurrence of loop flows, and the equality loop flow constraint mean that power will naturally balance around the loop to maintain this relationship.

Counter-price flows and negative IRSRs driven by the transmission loop are a natural and expected part of an increasingly interconnected system.

Figure 6 below shows the high-level processes in dispatch and settlements for the management and allocation of negative IRSRs. As discussed in Section 2 above some aspects of the process are as set out in the NER while others are delegated to AEMO for implementation.

Figure 6 Current IRSR dispatch and settlements process



Current design - Negative Residue Management (NRM)

The current design of NRM via constraint automation or "clamping" is not operationally efficient if negative IRSR occurs normally and frequently impacts interconnectors and adjacent regions. Reducing or capping negative IRSR through constraints treats negative IRSR as an unacceptable dispatch outcome, or one that is driven by inefficient market dynamics or constraints, not as an expected outcome of loop topology.

The current process of NRM applies where the accumulation of actual or forecast negative IRSR reaches -$100,000, with a NRM constraint equation specific to each directional interconnector automatically activated from the next TI. The use of the $100,000 constraint threshold was introduced to balance to cost and risk of negative IRSR accrual with the inefficiency of continued application of NRM constraints as an intervention in the market. The implementation of PEC and the resulting prevalence of negative IRSRs would result in a significant increase in the use of NRM constraints under the current process, that would likely create increased complexity in dispatch with the potential to distort market outcomes between regions and impact efficient utilisation of interconnector capacity.

NRM constraint equations act to constrain off counter-priced flows stepwise, with the size of the NRM constraint applied dependent on the scale and magnitude of the negative IRSR. For example, larger steps are typically applied for larger forecast or actual counter-priced flows. NRM constraint equations are only applied to the extent they do not impact power system security and have a lower constraint violation penalty factor than other security constraints, such as line limits and generating unit constraints.

It should be noted that NRM constraints are an input into NEMDE to minimise counter-priced flows, and therefore do not always prevent negative residues, and can also result in positive residues. It is not possible to apply a NRM constraint that equalises prices across the directional interconnector and results from applying the NRM constraint can sometimes be unpredictable, particularly in the presence of generator rebidding.

Typically, less generation in the exporting region is dispatched because of the constraint applying and this can cause the price in the exporting region to drop and positive residues to accrue, depending on whether the NRM constraint reduces flows to zero. The automation of NRM constraints does not immediately remove the constraint when this occurs, because upon withdrawing the constraint previous conditions, counter-price flows can quickly reoccur. The current process of NRM constraint equations is not designed for frequent application and not operationally efficient as a common driver of dispatch outcomes.

Further, with implementation of PEC, the normal occurrence of negative IRSR on one or two interconnectors while aggregate loop settlements residues are in surplus indicates negative residues in this circumstance are required to balance the loop and maximise efficient dispatch. Under these circumstances, negative IRSR should be treated as an acceptable dispatch outcome and a feature of loop flow topology, and not subject to negative residue management.

However, while the occurrence of aggregate loop settlement in deficit was modelled to be low, the results imply a requirement to retain some form of negative residue management constraints to try to prevent them. Negative residue management under these circumstances would seek to minimise the occurrence of negative IRSR driven by inefficient market dynamics and impacting aggregate loop IRSR outcomes.

Allocation of negative settlement residues

Under the current allocation of negative settlement residues to TNSPs, the introduction of loop flow IRSR would result in significant increases in negative IRSR distributed to the TNSP in the importing region. The allocation and recovery of negative IRSR is specified in accordance with NER 3.6.5(a) which sets out the principles for crediting and debiting of settlements residues. All negative inter-regional settlements residues attributed to a directional interconnector are allocated to the TNSP in the **importing** region[20] for cost recovery.

These costs are recovered by the TNSP from customers through increased network service fees. The costs of negative residues offset the proceeds paid to the TNSP from SRA units, which are used to reduce TUOS charges to TNSP customers.

[20] Importing region is defined in NER 3.6.5(a0) as the *region to which electricity is transferred during the relevant trading interval from another region through regulated interconnectors.*

The current process for allocation of negative IRSR to a single directional interconnector does not align with the meshed nature of loop flow topology. Where negative IRSR is accruing on a single directional interconnector, but settlement is in surplus around the loop, the negative IRSR is supporting the accrual and value of the positive IRSR into importing regions around the loop. Customers in regions with positive IRSR are therefore benefiting from the negatives attributable to customers in adjacent regions because the price is lower. The current allocation process does not account for the dynamics of balancing loop flow nor consider the value of positive IRSR transfer around the loop, and which customers are receiving the benefit of this value.

Positive IRSRs are paid to relevant unit holders that have purchased units through the SRA process for each relevant quarter. Any interconnector capacity that has not been sold through the SRA, such as unsold units or new interconnector capacity that has not been converted into SRA units, is paid to the importing TNSP.

A significant increase in negative interregional residues has also the potential to create working capital issues for TNSPs as regulated entities who forecast operating expenditure in advance and have, AEMO believes, effectively a two-year lag until they can account for the cash surplus or deficit in transmission prices. While this would be particularly problematic if AEMO removed NRM constraint clamping where settlements are in surplus around the loop, even if AEMO retained NRM constraint clamping for directional interconnectors under all outcomes, targeted at -$100,000, it is likely the higher incidence of negative IRSR would result in higher negative IRSRs accruing that would be allocated to TNSPs. AEMO considers a significant increase in negative IRSR to TNSPs would be problematic to manage under current processes, with TNSPs required to manage both cash flow issues and difficulty in the allocating negative IRSR between TNSPs in the loop.

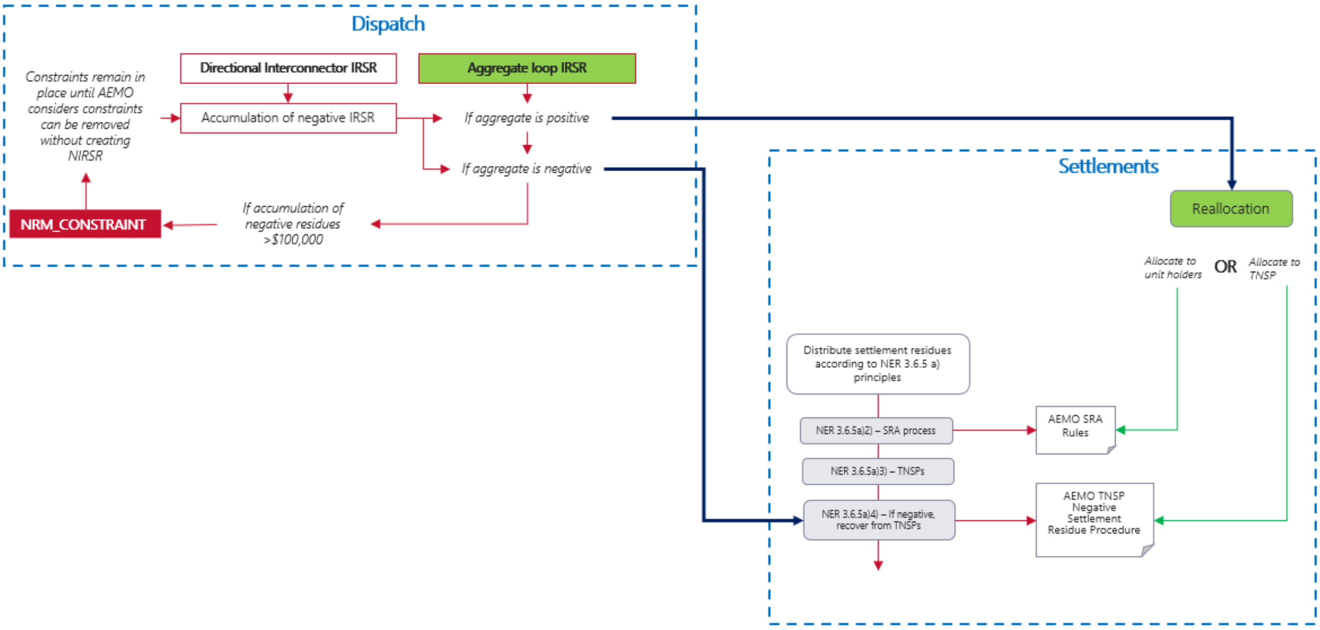
	Category	Questions for consultation
1	Current process	AEMO considers the current process is unsuitable and will restrict efficient dispatch. Are there any additional advantages or disadvantages with the current process identified by stakeholders that could apply in the context of transmission loop flows?

6 Approach

AEMO considers that amendments to the NRM process and the distribution of negative IRSR may effectively account for the changed physical dynamics between the adjacent regions and seek to align the settlement outcomes of transmission loops with the relevant drivers.

This section discusses changes to NRM and proposed approaches to the distribution of IRSR that would apply in the most common dispatch outcome – when aggregate loop IRSR is in surplus, but negative IRSR occurs on one or two interconnectors. Section 6.3 also includes discussion of who payment for negative IRSR in this scenario. Figure 7 below, proposes two key additional steps in green – the real time monitoring of aggregate loop IRSR and the settlements reallocation of negative IRSR, where aggregate IRSR around the loop is in surplus.

Figure 7 Reallocation approach for IRSR dispatch and settlements process



6.1 Negative residue management

Following the implementation of PEC, negative residue management may still be required but limited to apply only when aggregate settlement is in deficit, which is when interregional settlement residues are ”net negative” around the loop. This aligns with the original design of NRM clamping, that is, to manage the accumulation of inefficient counter-price flows, when there is not enough money to pay generators in settlement. This approach would then allow negative IRSRs to accrue in dispatch when aggregate settlement residues around the loop are in surplus – thereby considering this scenario as an efficient dispatch outcome and acknowledging the surplus accruing around the loop is in part, driven by occurrence the negative IRSR on a subset of interconnectors.

This approach would require consideration of the feasibility of monitoring and automating NRM constraints which account for aggregate IRSR outcomes. This may involve retaining NRM constraints for directional interconnectors but only invoking them when aggregate IRSR is in deficit and negative IRSR as accrued on a directional interconnector is heading to the threshold of $100,000. This would largely retain existing processes of the application of NRM constraints for the incremental[21] and stepwise clamping of counter-priced flows specific to each directional interconnector. The threshold level of $100,000 could be likewise retained as the level that balances minimising both intervention in the market risk and the risk of increased payments for negative IRSR – however this may require further consideration.

Having said that, transmission loop flow and the loop flow constraint mean that applying the NRM constraint to a single directional interconnector will directly impact power flow and balance around the loop. AEMO currently applies and releases this clamp in incremental targets of interconnector flow. While exact outcomes will be diverse and specific to the operating conditions that have caused the aggregate negative residues, stopping counter-price flows on a single directional interconnector will cause rebalancing and changes to aggregate outcomes around the loop. It is not guaranteed the NRM constraint will ensure settlement balances, because the other interconnectors in turn may accrue negative IRSR. If NRM constraints were then applied to each interconnector in turn it is not possible that under the equality constraint for all interconnectors to be clamped to zero flow, and it is possible one or more may violate, because NEMDE would not be able to satisfy all constraints. This aligns with the interconnected nature of the meshed system.

The proposed negative residue management approach does not seek to detail all possible outcomes, instead noting possible effects include:

- Increased negative IRSR on other legs of the loop.
- Cycling of negative IRSR around the threshold on the directional interconnector where the clamp has been placed.
- Changes on settlement outcomes around the loop (negative or positive).

These impacts however should not be considered as resulting from proposed approach to only clamp flow when there is negative IRSR in aggregate around the loop. They are possible and likely outcomes from loop flow topology and the negative residue management regardless of the exact process to do. The proposed approach seeks to limit the extent to which intervention via clamping constraints is required in a system where loop flows increase the prevalence of counter-priced flows. Limiting the application of interconnector clamping to when aggregate loop IRSR is negative, seeks to limit the extent to which interconnector clamping is a driver of dispatch outcomes.

Alternative approaches considered:

1. Retain NRM as is and apply interconnector clamping where directional interconnector negative IRSR is >$100,000 (current process)

   This approach is considered not fit-for-purpose as it does not reflect the dynamics of an increasingly meshed power system. Intervention in the market via NRM would be applied significantly more frequently, and inefficiently and in circumstances where counter-price flows between regions are driven by loop network topology and negative settlements may be reallocated around the loop.

2. Remove NRM for PEC, Heywood and VNI in all scenarios.

   Complete removal of NRM for transmission loop interconnectors increases the risk of negative IRSR accruing in large amounts on specific directional interconnectors, with costs ultimately borne by consumers. This approach would be preferrable if the transmission loop network topology would largely

[21] Clamp increments are not symmetrical when applied and released. The clamp is applied in greater increments to halt the accrual of negative IRSR than when released. Interconnector clamp is only applied where power system security is maintained.

prevent the occurrence of settlements in deficit or negative IRSR in aggregate around the loop. Negative IRSR would then largely be removed by reallocation around the loop. Modelling results demonstrate that while positive IRSR in aggregate is the prevailing scenario, negative in aggregate can occur driven by disorderly bidding and intra-regional constraints. Section 2.2.2 of ACIL Allen modelling report tested scenarios where negatives are in aggregate around the loop (as described below).

Modelling results - Negative in aggregate

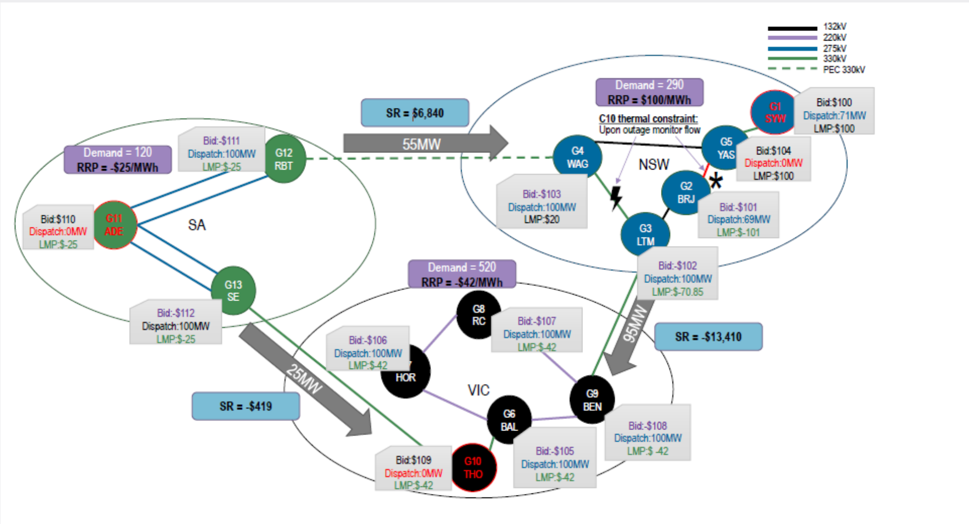
The below scenario demonstrates the impact of binding intra-regional constraints and the occurrence of negative pricing in aggregate around the loop. As described in the ACIL Allen report page 21:

"*There is a high level of negative IRSR between VIC and NSW caused by the negative bid of G3 which is dispatched to minimise the total system cost even though it does not supply the local NSW load on the other side of the constraint".*

The binding C10 constraint in NSW prevents optimal intra-regional flows and forces southward flow along VNI. The higher price within NSW demonstrates the cost of congestion within the region and the impact of generator nodal bidding while price is set at the regional reference node.

Negative IRSR also occurs on Heywood with counter-price flow from SA to VIC, demonstrating the impact of transmission loop flows and the loop constraint balancing flow around the loop. This example demonstrates the relationship between and impact of intra-regional constraints and the loop flow constraint on settlement outcomes.

Scenario results – negative in aggregate



	Category	Questions for consultation
2	Approach	AEMO considers regulatory precedent requires negative residue management be retained for periods where IRSR is in deficit around the loop, that this be automated as far as possible, and limited to $100,000 and any accruing negative residues be allocated to the importing TNSP.

	Category	Questions for consultation
		For these instances, there would not be any reallocation required. Are there any other approaches to negative residue management AEMO should consider?

6.2 Reallocation of IRSR

AEMO considers a new methodology is required to distribute negative IRSR around the loop. The implementation of PEC and the resulting loop between regions, creates an inextricable link between each directional interconnector around the loop. Settlement outcomes, both positive and negative are related and are a direct product of each directional interconnectors power flow. The outcomes on each directional interconnector may therefore need to be thought of differently to today, as a meshed network does not allow consideration of a single directional interconnector without the impact on outcomes around the loop.

This section discusses reallocation of negative IRSR around the loop to reflect the changing power flow dynamics and the role the negative IRSR on one interconnector has on delivering positive IRSR on other directional interconnectors. This methodology seeks to reasonably align the costs for negative IRSR with the regions who may be benefiting from the occurrence of negative residues around the loop. This methodology would apply where one or two directional interconnectors IRSR is negative but settlements in surplus around the loop, acknowledging that in part the negative IRSR is allowing for the increased value of positive IRSR.

This section describes two approaches for the distribution negative IRSR around the loop: 1) the reallocation of negative IRSR only and 2) allocation of all IRSR. AEMO considers the reallocation of negative IRSR only best aligns the costs of negative IRSR with transmission loop dynamics and minimises the impact on settlement outcomes.

1. Reallocation of negative IRSR

The reallocation of negative IRSR would redistribute the negative IRSR only to the directional interconnectors and regions, who have received positive IRSR for each specific trading interval. The preferred method for reallocation is to reallocate the negative IRSR to the positive regions, based on the relative ratio of positive IRSR accrued on each directional interconnector specific to the trading interval.

This approach would seek to spread the impact of negative IRSR around the loop in alignment to the transmission loop flows that are affecting settlement outcomes. Negative IRSR where aggregate settlement is in surplus, is in effect occurring to allow optimal dispatch outcomes and power flows around the loop. The reallocation of negative IRSR to interconnectors with positive IRSR reflects the role counter-priced flows are having in allowing positive interconnectors to achieve those flows.

This reallocation approach would ensure that all regions receive at least zero residue by applying a 0 for each trading interval to the directional interconnector with negative IRSR. This could be thought of as essentially scaling down the absolute value of positive interconnector IRSR, to remove the cost of the negative IRSR from the importing region.

This reallocation method of negative IRSR may be applied to distribute negative IRSR in alignment to transmission loop flows, regardless of who pays for them, to unit holders (netting against positive SRA distributions) or the TNSPs (cost recovery). Discussion and consideration of who is best placed to pay for negative IRSR is included in Section 6.3.

Example reallocation method – retaining ratio of positive IRSR accrual:

Where there is a single negative directional interconnector e.g. SANSW

Original ratio of positive residues: $IRSR(SAVIC){:}\,IRSR(VICNSW)$

Aggregate around the loop $IRSR(loop) > 0$

Negative reallocation:

$$Negative\ IRSR(SAVIC) = \left[\frac{IRSR(SAVIC)}{IRSR(SAVIC) + IRSR(VICNSW)}\right] * \ negative\ IRSR(SANSW)$$

$$Negative\ IRSR(VICNSW) = \left[\frac{IRSR(VICNSW)}{IRSR(SAVIC) + IRSR(VICNSW)}\right] * negative\ IRSR(SANSW)$$

This is a dynamic method that considers the relative interregional dynamics of both price and MW flow around the loop. Settlement outcomes continue to reflect congestion and pricing dynamics between regions, while taking into account the effect the loop flow constraint has on spreading power flow around the loop and therefore aligning the reallocation of negative IRSR with regions with the capacity to pay for the negatives.

AEMO has primarily assessed this reallocation method based on reallocating negative IRSR to positive directional interconnectors on a per interval basis e.g., every TI where aggregate loop IRSR is positive, but IRSR is negative on a subset of lines. An alternative approach may be to assess aggregate loop IRSR and directional interconnector IRSR on a weekly, monthly, or quarterly basis and reallocate negative IRSR in aggregate based on the time selected. This approach is not preferred as market outcomes may be significantly distorted when assessing negative and positive IRSR on an inter-temporal basis. An intertemporal netting creates a cross-subsidy between periods and leads to diminishment of marginal price signals, difficulties accounting for the settlement, the dispatch effects and loss of efficiency.

Alternative reallocation methods:

- Coefficient – reallocate negative IRSR based on the coefficients of the loop flow constraint PEC =1, Hey = 0.8 and VNI =0.14. This approach is a static approach that is likely to distort IRSR market outcomes as it does not consider the changing dynamics of each interval. When applied to all aggregate IRSR, it significantly changes the spread of positive residues, increasing skew towards PEC and Heywood due to the higher loop flow coefficients.
- Flow – reallocation is based on the relative ratio of MW power flow on each directional interconnector. This approach is dynamic and will vary depending on the power flows for each TI. This is similar to the preferred reallocation method, however the flow approach does not take into account the relative price dynamics between regions – only the distribution of power flow, resulting in increased variability in residue allocation from dispatch outcomes.

2. Allocation of all IRSR

Instead of reallocating negative IRSR only, an alternative approach that accounts for the meshed and interdependent nature of the transmission loop, is to change the primary allocation of all loop IRSR. This would use a defined allocation methodology, as described above, but distribute net positive IRSR around the loop (instead of only negative IRSR as described above).

The IRSR allocation approach would remove the concept of negative and positive IRSR on a single interconnector, instead calculating and distributing IRSR allocation based on aggregate loop IRSR. As with the reallocation of negative IRSR, the IRSR allocation approach would only need to apply when there is settlement in surplus around the loop with negative IRSR on one or two interconnectors.

The method for IRSR allocation may use the same principle as the above negative reallocation method - i.e., IRSR is allocated to each interconnector based on the relative value of IRSR accrued on each interconnector. This approach maintains the same principle of using IRSR ratios as the above negative reallocation method but would use the ratio of absolute IRSR both positive and negative. Each interconnector IRSR allocation would be calculated as:

$$IRSR(SAVIC) = \left[\frac{abs(IRSR(SAVIC))}{abs(IRSR(SANSW) + abs(IRSR(SAVIC)) + abs(IRSR(VICNSW))}\right] * IRSR(aggregate\ loop)$$

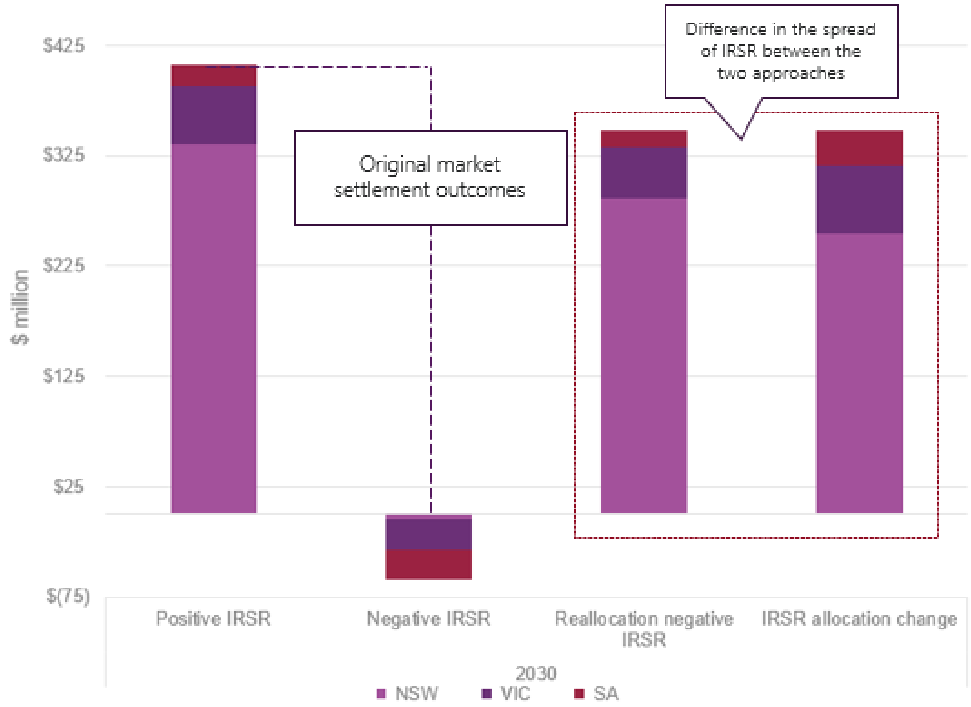
The key difference between this approach and the reallocation of negative IRSR only, is that the allocation of all IRSR would allow for some positive IRSR to be distributed to original interconnector with negative IRSR. This would have the increased effect of spreading IRSR around the loop. By contrast, the reallocation of negative IRSR applies zero IRSR to the negative interconnectors by reallocating only the negatives around the loop.

3. Comparison of reallocation of negative IRSR and IRSR allocation approaches

Figure 8 below show an example of the differences in distribution of IRSR under the reallocation and allocation change methodologies. Sample data shown the uses the results from ACIL Allen's modelling using the PST 2 setting. IRSR results are aggregated to the importing region and calendar year.

Under the allocation of all IRSR approach, there is further spreading or change from the original distribution of IRSR, although the overall impact is minimal over the year. As shown for year 2030, in this example, NSW is the primary importing region and has the highest amount of positive IRSR from market outcomes. While this is shown as further scaled down under the IRSR allocation approach, Figure 8 demonstrates that both approaches reasonably retain the distribution of positive IRSR to the importing region and aligns the costs of counter-priced flows with the regions with capacity and benefit of flows to pay for it. Neither method indicates a significant distortion of IRSR or distribution to regions who are export or import-export regions around the loop.

Figure 8 Comparison of approaches negative reallocation and IRSR allocation change



AEMO considers that both the reallocation and allocation approach represent a reasonably robust approach for the distribution of IRSR within a transmission loop. AEMO considers the reallocation of negative IRSR preferrable as it:

- **Allows for consideration of whether negative IRSR should be deducted from payouts to unit holders.**
  - Under the reallocation of negative IRSR approach, negative IRSR can be directly recovered from consumers in the importing region (via TNSPs as per the current process) or deducted from SRA unit holders. As the allocation of all IRSR approach does not separate negative and positive IRSR, it assumes that unit holders will pay for the negative IRSR as allocations of net IRSR around the loop are distributed.
  - Section 6.3 below discusses the relative merit of deducting negative IRSR from unit holders, however this is not applicable to the allocation of all IRSR allocation approach. As AEMO's preliminary policy position (discussed below) is to not deduct negative IRSR from unit holders, the allocation of all IRSR approach is not fit-for-purpose.
- **Does not allocate positive IRSR to interconnectors where negative IRSR has occurred.**
  - When negative IRSR occurs, customers in regions importing counter-priced flow are already realising the benefits of paying a relatively lower price for supply, and therefore do not need the additional benefit of distributions of positive IRSR. Distributing positive IRSR to regions where negative IRSR has occurred, reduces the IRSR distributions on the other interconnectors (they can afford to pay for the negative IRSR).
  - By retaining and auctioning the full residue to that interconnector (and not reducing it by deducting negative residues of other interconnections), the SRA should better reflect price differences between regions and be more useful to support interregional trading.

	Category	Questions for consultation
3	Approach	In considering the reallocation approach, AEMO considers a sensible method is to allocate negative residues is in proportion the with positive residues on the other interconnectors in the loop. AEMO considers it is preferrable that an interconnection that is negative not receive a proportion of the positive residues. Do stakeholders agree?
4	Approach	Do stakeholders consider these approaches to be reasonably robust, irrespective of whether negative IRSR is deducted from the payouts to SRA unit holders?
5	Approach	Do stakeholders have a different method for the reallocation of negative IRSR that should be considered?

6.3 Payment for negative IRSR – whether to deduct from SRA unit holders

Assuming the reallocation of negative IRSR method above is agreed, the next decision is to determine whether negative IRSR should be charged directly to consumers in the importing region or whether it should first be deducted in the calculation of IRSR available for distribution to unit holders by reducing the payout of units purchased in the SRA. This decision comes down to whether the allocation of negative IRSR will diminish units' utility and therefore their auctioned value, to an extent greater than the deductions of negative IRSR.

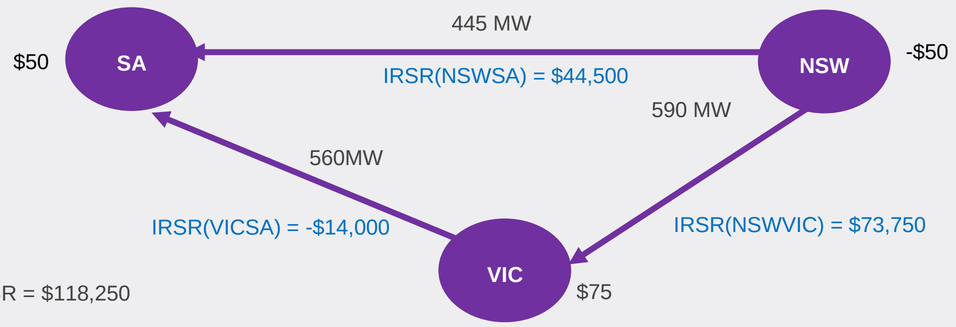
1. Deduct negative IRSR from the IRSR payout to SRA unit holders

Reallocated negative residues could be allocated to unit holders, by netting reallocated negative IRSR against positive IRSR around the loop. This process should be applied based on settlement outcomes on a per interval basis, allowing negative IRSR to be directly recovered from positive IRSR that was accrued in the loop and benefited from counter-priced transmission loop flow.

Allocation to the unit holders would introduce additional uncertainty associated with IRSR distributions and consequently SRA unit value. The purchasing of SRA units is highly speculative with a range of possible outcomes and market uncertainties that affect the price different and magnitude of flow between two regions. The process of netting of negative IRSR from positive IRSR around the loop will likely further decrease the firmness of units as an additional speculative variable that must be accounted for. This may decrease the trading performance of SRA units and reduce the value of the SRA as a tool to manage interregional basis risk, as unit holders may need to account for the repricing and transfer of risk based on the reallocation methodology. Further discussion on the impact on the SRA is included in Section 7, including noting the implementation of PEC itself will have a more significant impact on IRSR distributions and SRA value, than the reallocation of negative IRSR.

Previous regulatory decisions have shifted the allocation of net negative IRSR to the TNSPs and removed netting negative IRSR from positive IRSR, as the practice was considered to reduce SRA unit firmness without significant benefit or clear distribution of negative residues to customers who benefited from counter-priced flow. Whilst acknowledging previous determinations, it is worth noting the potential netting against positive residues would occur on a per interval basis instead of the previously weekly process. Further, the loop constraint means positive residues cannot accrue without the negative ones, and hence deducting the negative leg of the loop IRSR from the positive legs may better reflect the real value of the interconnector units in overall dispatch.

Example: Deduct negative IRSR from payouts to SRA unit holders



Reallocation:

Total positive IRSR = $118,250

Negative IRSR(NSWVIC) = $73,750/ $118,250* -$14,000 = -$8,732

Negative IRSR(NSWVSA) = $44,500/ $118,250* -$14,000 = -$5,269

If allocated to the unit holders, final IRSR for each directional interconnector:

VICSA = $0 **NSWVIC** = $65,019 **NSWSA** = $39,232

Unit holders	Impacts
VICSA	Negative IRSR is removed from VICSA, but unit holders do not receive distribution of positive IRSR Unit holders do not need positive IRSR as an interregional price hedge as the importing price (SA) is lower than the exporting price - Customers are already realising lower prices in SA and any generators in VIC are receiving the higher exporting price (VIC) and do not need the SRA unit to offset a derivative sold on the SA price, where they must pay the floating price.
NSWVIC	Positive IRSR –from positive flow (importing) Receives reallocated negative IRSR – NSW can flow towards VIC because SAVIC is flowing counter-priced , unit holders receive positive IRSR distributions – hedge against the price difference between NSW and VIC, but this is lessened by the deduction of negative IRSR from the VICSA interconnector.
NSWSA	Positive IRSR –from positive flow (importing from NSW) Receives reallocated negative IRSR – positive IRSR is reduced. Unit holders receive positive IRSR distributions, – hedge against the price difference between NSW and SA, but this is lessened by the deduction of negative IRSR from the VICSA interconnector.

2. Negative IRSR reallocated, in proportion to positive IRSR, to consumers in the importing regions

Under this option, the current principle of directly recovering negative IRSR from consumers in the importing region would be maintained. Reallocation to the importing consumers would mean that both negative IRSR where the aggregate loop is in deficit and reallocated negative IRSR where the aggregate loop is in surplus would be borne by the importing consumers. Assuming the SRA sales achieve fair value, the negative IRSR that is reallocated (when settlement is in surplus) should generally be offset by increases in the proceeds from the SRA, because traders should be willing to pay more for units (because there is no deduction from reallocated negative IRSR).

Because IRSR is economic surplus from transmission assets, SRA auction proceeds are used to reduce TUoS consumers must pay and is therefore paid to TNSPs by AEMO. Treating net negative IRSR in the same way, as economic surplus from transmission, is problematic. This is because the NEM's regional settlement model can produce net negative IRSR from both economic dispatch or more commonly from bidding that is not cost reflective. This is why the NER treats net negative IRSR as undesirable.

Selling IRSR via the SRA auction allows for TNSPs to turn a highly variable cashflow into a relatively fixed payment, more suited to the calculation and publication of annual TUoS prices. Ignoring negative IRSR, the SRA transforms a variable cashflow of IRSRs into one that is more predictable, and therefore provides a useful working capital, or cashflow service to the TNSP.

Recovery of negative IRSR from TNSPs is performed under a weekly billing and recovery from the TNSPs. Payments for negative IRSR are due 14 business days after the end of the billing week. If negative IRSRs are allowed in dispatch when settlement is in surplus, and these are substantial, this would impose working capital on TNSPs, because the TNSP would not simultaneously be receipting positive settlement residues from dispatch, instead receipting fixed auction proceeds.

If we assume consumers need fixed tariffs, there is an underlying requirement to manage the working capital requirements that arise from variations in cashflow caused by IRSR and negative IRSR. At present, for positive IRSR, this is performed by Traders when they buy units, because they provide to the TNSP a fixed cashflow in exchange for a variable one.

For negative IRSR it is managed by TNSPs and mitigated by AEMO's treating negative IRSR as an inefficient dispatch outcome.

If negative IRSR when settlement is in surplus is treated as an efficient dispatch outcome, and negative IRSR is not deducted from positive IRSR distributed to unit holders, the TNSP retains a fixed cashflow but takes on a larger, variable cashflow of negative IRSR.

Table 3 below shows the variation of negative IRSR settlement from ACIL Allen modelling results. Negative IRSR represented approximately 10-14%[22] of the value accrued when settlement is in surplus around the loop.

Table 3 ACIL Allen modelling results – Estimated negative IRSR, when aggregate settlement is in surplus

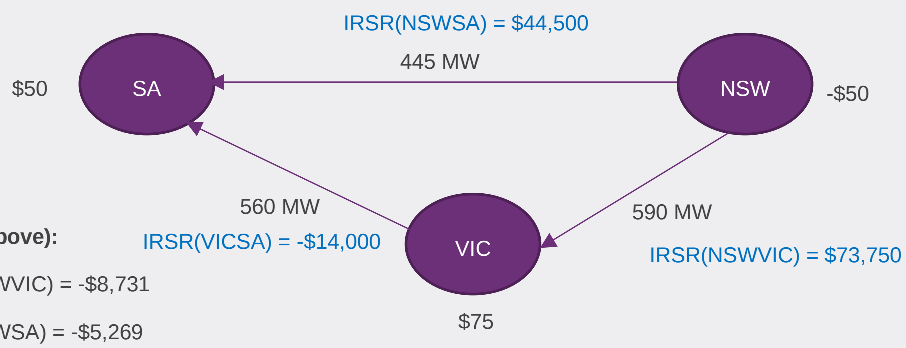
Year	2027	2028	2029	2030
Negative IRSR, where settlement is in surplus	$23M -$30M	$29M - $46M	$23M - $40M	$51M - $77M

If the hedging value of the units is prioritised, (where negative IRSR is not deducted from the positive IRSR distributed to unit holders), managing the cashflow of negative IRSR might become a more burdensome task than today, where negative IRSR are mitigated in dispatch. AEMO's preliminary view is this cashflow service or function should not be prioritised over preserving the hedging value of the units.

[22] Variation is based on modelled year and PST setting

The TNSP treasury function must manage variations in cashflow unsuited to a business whose cashflows are usually stable and predictable. The timing of recovery from consumers through increased TUOS charges does not align with the weekly negative IRSR liability, instead TNSPs would incur a two-year lag before the negative IRSR affects TUoS. As TNSPs are not required to provide prudential or credit support to AEMO, any default risk would impact the ability to settle the market as required under the NER.

Example: TNSPs pay for negative IRSR



Reallocation (as above):

Negative IRSR(NSWVIC) = -$8,731

Negative IRSR(NSWSA) = -$5,269

If allocated to the TNSPs, distribution of funds

VIC customers pay = -$8,732 **SA customers pay** = -$5,269

Customers	Receiving (credit):	Paying (debit)
SA	Importing power from both VIC and NSW – customers receiving lower prices than may have otherwise been possible Positive IRSR is accruing on NSWSA - SRA auction proceeds are allocated to SA customers as the importing TNSP	Payment for reallocated negative IRSR
VIC	Importing power from NSW – customers receiving lower prices than may have otherwise been possible Positive IRSR is accruing on NSWVIC – auction proceeds allocated to VIC customers as the importing TNSP	Payment for highest portion of reallocated negative IRSR
NSW	Customers are paying the lowest price Region is exporting,– no need to allocate negative IRSR because customer payments are already needed to pay generators in NSW	

	Category	Questions for consultation
6	Approach	Which option best meets the guiding principles identified in Appendix A3? Are the other options that also meet the guiding principles that should be considered?
7	Approach	Should AEMO propose a method that deducts negative IRSR from the payout to SRA unit holders; or reallocates negative IRSR, in proportion to positive IRSR, directly to consumers in the importing regions?
8	Approach	What, if any, other factors need to be included when considering the payment for negative IRSR?

7 Implications for the Settlement Residue Auction

This section discusses the implications for the SRA, including auction timings, the treatment of units and resulting participation and function in the SRA.

7.1 IRSR

The implementation of PEC introduces significant variability and uncertainty of interregional flows. While the broader benefits of PEC are expected to be material, the firmness of SRA units as per the current design and their effectiveness to hedge inter-regional price risk and promote competition in contracting markets will change by an increasingly meshed network.

The purchasing of SRA units may need to be considered differently to today. For example, regardless of a change to reallocation of negative IRSR, the purchase of a single directional interconnector will be affected by the outcomes of the transmission loop and the power flows across the now three adjacent regions.

The relationship between the auction proceeds to the TNSP and unit holders' entitlement of IRSR means that where the value of SRA units as a financial hedge increase, auction proceeds should similarly increase to TNSPs. Increasing volatility in the market and the likelihood of price separation between regions would typically increase the value of IRSR distributions. However, expected project benefits from PEC are lower dispatch costs and decreased price separation through increasing access to supply options across regions. It may therefore be considered that in addition to increased uncertainty of power flows in the region, PEC implementation may reduce interregional price risk and price separation between regions. This may increase interregional trading.

Whilst the purchase of SRAs is speculative, the introduction of PEC and any possible reallocation of negative IRSR and deduction from unit holders represents additional variability for participants bidding in the SRA.

7.2 Treatment of impacted units

This section sets out proposed process for the treatment of units on existing directional interconnectors (VICNSW, NSWVIC, SAVIC and VICSA) that may be impacted by a change to the reallocation of IRSR if deducted from unit holders.

While there is uncertainty regarding changes to the recovery of negative IRSR, AEMO will seek guidance and approval from the Settlement Residue Committee (SRC) on the treatment of impacted units.

Impacted units that have already been auctioned

While the timing is estimated, AEMO has identified there may be units on impacted directional interconnectors (VICNSW, NSWVIC, SAVIC, VICSA) that have already been sold for quarters after which PEC Phase 2 may have commenced to have a material impact on IRSR outcomes. Current expectations are that units already sold relating to 2026 Q1, Q2 and Q3 may be the first to be impacted.

AEMO considers that potential changes to the reallocation of IRSR if reallocated negative IRSR is deducted from unit holders are reasonable grounds for unit holders to terminate an SRDA if they no longer want to retain the already purchased allocations of impacted units. Section 16.5 of the Auction Participation Agreement (APA) allows an Auction Participant to terminate a Settlements Residue Distribution Agreement (SRDA)[23] if there is a change in the way in which settlements residue is calculated that has an effect on the calculation of settlements residue the subject of the SRDA. If terminated, remaining units that were the subject of that SRDA at the time of termination may be reauctioned in later tranches.

Impacted units in future auctions

Units will continue to be auctioned on impacted directional interconnectors in tranches until the relevant quarter. AEMO will seek SRC feedback and approval on two possible approaches to the treatment of impacted units on future auctions:

- **Continue auctions, noting that participants may be able to terminate impacted units.** AEMO will seek feedback from the SRC on continuing auctions as per the current schedule and if the methodology for the allocation of IRSR changes to deduct negative IRSR from unit holders, unit holders may be eligible to terminate impacted units. AEMO would work with the SRC to confirm timings for terminating units and include any impacted units in subsequent auctions prior to the relevant quarter.
- **Temporarily suspend auctions**. While the consultation on this Paper is underway, consider suspending the SRA for impacted interconnectors as per NER 3.18.2(d). Auctions would recommence once the methodology for the allocation of IRSR is finalised. Impacted units that have would have been auctioned would be sold by increasing available tranches of units at future auctions. AEMO would need to work with the SRC to confirm and communicate a process for recommencing the SRA. Consideration would need to be given to the impact on secondary trading, as participants would have less opportunity across 3-year period to purchase and resell in future tranches.

[23] AEMO, Auction Participation Agreement - https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/market-operations/settlements-and-payments/settlements/settlements-residue-auction/auction-participant-agreement

8 Implementation and next steps

The section describes the implementation requirements and consultation timings.

8.1 Implementation considerations

Rule changes

AEMO is working under the assumption that these changes to the reallocation of negative IRSR would require an amendment to the NER principles for the allocation and distribution of settlements residue by AEMO. Specifically, NER 3.6.5(a)(4) and NER 3.6.5(a)(4A) that allocates, distributes or recovers settlement residue by AEMO in accordance with the principles to the appropriate TNSP. Further, terms under NER 3.6.5(a)(4B) are being considered for its application in loop topology.

Under the reallocation approach, the TNSP would still be responsible for negative settlements residue which is retained as aggregate loop negative residue is in deficit. An additional and specific NER amendment may be required to allow and delegate to AEMO to set out a reallocation process for the negative settlement residues where aggregate loop IRSR is in surplus. This would be limited to impacted interconnectors in the adjacent regions.

Procedure and system changes

Further investigation is required to determine the feasibility of maintaining negative residue management only where aggregate loop flow is in deficit around the loop. This includes required changes to the AEMO procedures for the management of negative residues in dispatch, Dispatch Procedure (SO_OP_3705) and the supporting Brief for the Automation of Negative Residue Management. Changes to these procedures would be subject to stakeholder consultation as per the procedure change guidelines.

The implementation of a reallocation approach would require also updates to AEMO's settlements systems and detailed processes. This would include a procedure change process for the Distribution and Allocation of Settlement Residues. Corresponding changes to unit holders' and/ or TNSPs' market systems may be required.

	Category	Questions for consultation
9	Implementation	The reallocation approach would require updates to AEMO's settlement systems and procedures. What does AEMO need to consider in terms of: - Participant or TNSP market and settlement systems? - Timing of implementation?

8.2 Next steps

This paper seeks to set out the issues and approach to the management and allocation of transmission loop flow arising from the implementation of Project Energy Connect. Results and discussion presented are for stakeholder consideration and feedback. Following stakeholder feedback, AEMO intends to finalise recommendations and initiate relevant rule and procedure change processes.

AEMO welcomes stakeholder feedback on this paper. Written submissions are requested to NEMReform@aemo.com.au by 1 December 2023.

A1. Regulatory framework

Relevant NER clauses

Rule	Summary
3.8.1 (b)	Requires AEMO to maintain dispatch to maximise the value of spot trading, subject to ...
3.6.5 (a)	Requires AEMO to allocate and distribute settlement residue in accordance with principles for allocation. Settlements residue should first take any jurisdictional requirements into consideration before being distributed in accordance with the SRA process. Any remaining settlements residues should be distributed to be appropriate TNSP.
3.8.1(b)(11)	… the management of negative *settlements residue*, in accordance with clause 3.8.10 and any guidelines issued by AEMO under clause 3.8.10(c).
4.6.6(b)(1)	Specifies that the management of negative settlement residues should be done in accordance with 3.8.10 constraint formulation guidelines
3.6.5(a)(4)	Provides for the recovery of negative settlements residue by AEMO from the appropriate TNSP. The appropriate TNSP is defined as the TNSP the importing TNSP.
3.18	Specifies for the requirement for Settlement Residue Auctions (SRAs), including the requirement for AEMO to develop the auction rules, the distribution of SRA proceeds and the establishment and role of the Settlement Residue Committee (SRC).

Relevant procedures and guidelines

Dispatch Ops (SO_OP_3705) – Specifies the negative residue management approach, including the operational response from AEMO where the accumulation of counter-price flows is forecast to reach the threshold value of $100,000[24].

The NRM process is maintained in AEMO's Dispatch (SO_OP_3705) operational procedure and is delegated to AEMO within NER 4.6.6.6(b)(1) requiring AEMO to manage the accrual of negative residues in accordance with constraint formulation guidelines.

Brief of automation of negative residue management – Provides information on the automated constraint processed used in NEMDE to limit further accumulation of settlement residues once the threshold value is reached.

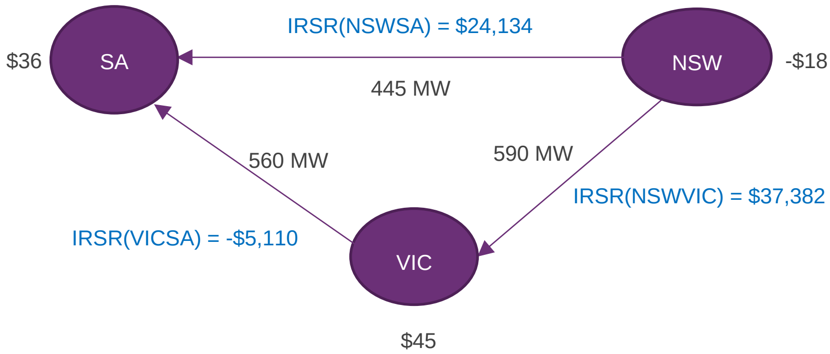
Methodology for the allocation and distribution of settlements residues – Describes the methodology used by AEMO to allocate settlements residue in accordance with NER 3.6.5a), including allocation to the directional interconnector and recovery of negative IRSR from the TNSP.

NEM Transmission Network Service Provider Negative Settlements Residue Procedure – Sets out information and procedure for the recovery of negative settlement residues under NER 3.6.5a) (4), including the settlement cycle and payment process.

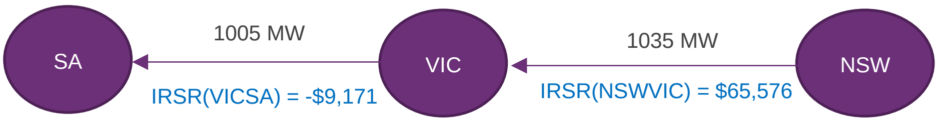
[24] Insert reference to AEMC review of interregional settlement residues in 2013?

A2. Dispatch integration models

Example 1: VIC operating as transitory import-export region



In this example, VICSA and NSWSA are both flowing towards SA. This would be represented in a micro-slice by a single increased flow on VICSA as sum of the VICSA and the NSWSA flowing to SA, and a single increased flow on NSWVIC as the sum of NSWVIC and NSWSA.

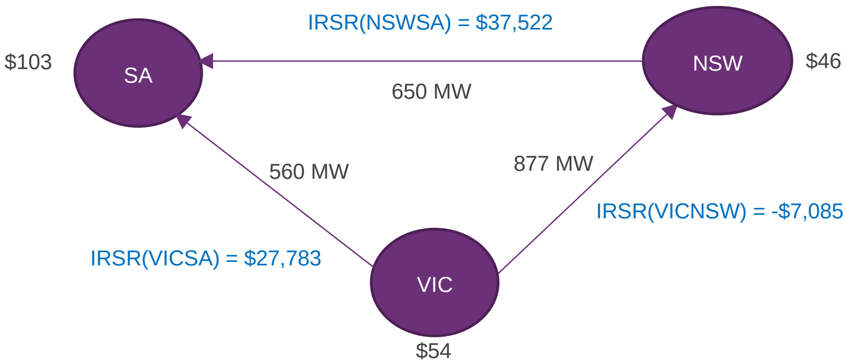


The IRSR allocation for each interconnector is then calculated as the flow on each line multiplied by the difference between VIC-SA and NSW-VIC prices. There is no longer any relationship between NSW and SA prices in settlements as the micro-slice calculates all flows through VIC. This affects the gross value of IRSR (both positive and negative) between the three regions.

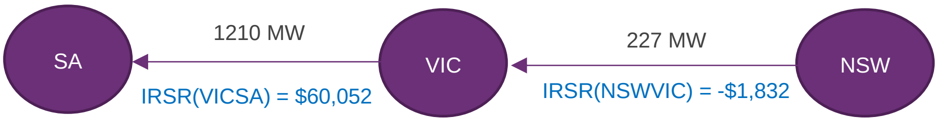
In this example, both negative IRSR and positive IRSR are inflated under the micro-slice model. Customers in SA are therefore paying more for negative IRSR in the micro-slice example. This also has the effect of removing all positive residues attributable to SA customers and transferers increased IRSR to VIC customers. This significant increase of IRSR to VIC customers does not represent the value of flows around the loop and between the three regions, as VIC is largely acting as an import and export region with SA customers receiving and paying for the power flows along PEC.

Example 2: NSW is operating as a transitory import-export region

Example 2 demonstrates the function of the micro-slice when flow on PEC (NSWSA) is flowing in the opposite direction to one of the other interconnectors (VICNSW). In this case the negative IRSR accrued on VICNSW is decreased as the counter-priced flow on VICNSW and offset by the flow on NSWSA.

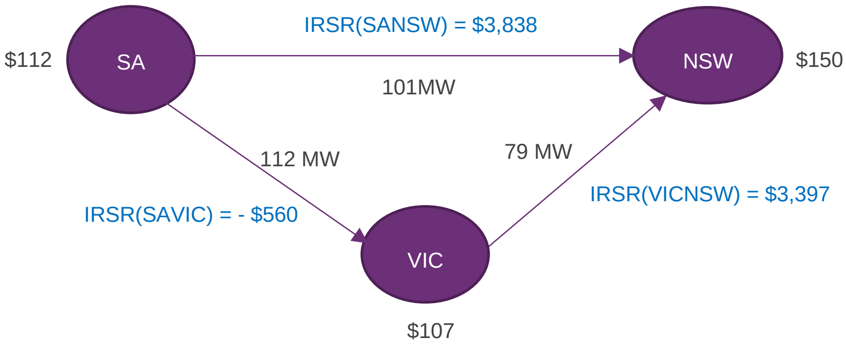


In this example, VICNSW and NSWSA are flowing different directions, so the capacity represented in a micro-slice model on VICNSW is significantly less than the actual flows across VNI.

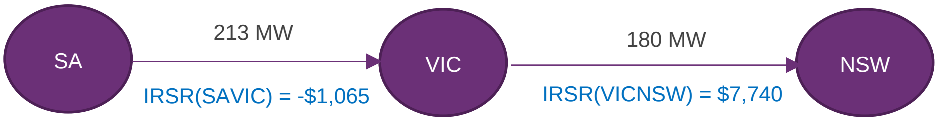


The IRSR gross value of both positive and negative IRSR have decreased in this example. There is a reduction in VICSA positive IRSR all 1210 MW of flow into SA is calculated against the smaller price different between SA and VIC, instead between SA and NSW as well. The negative IRSR attributable to NSW also reduces as the size of the counter-priced flow VICNSW (877MW) is reduced by the exporting flow along PEC to SA. NSW customers are paying less for negative residues under the micro-slice model which, in this example, accurately reflects the import export role NSW is having in transferring value around the loop.

Example 3. SA exporting to NSW



In this example, SA and VIC are exporting to NSW where the highest price around the loop. Intra-regional constraints within NSW are causing the initial mispricing between regions, with the transmission forcing counter-priced flow on SAVIC.



As all interconnectors are flowing towards NSW, the micro-slice example represents SAVIC and VICNSW as the full flows on the parallel lines as PEC is flowing the same direction as SAVIC and VIC NSW. Both positive IRSR and negative IRSR increase as the full flow NSW importing into is calculated relative to the lower VIC price, and there is a higher amount of MW flow considered as counter priced along SAVIC.

In this example, VIC is acting as an import-export region with most power from SAVIC transferred along VICNSW. The micro-slice model does not account for the transitory role VIC has in this example of transferring power around the loop, instead allocating the full and inflated amount of negative IRSR to the VIC region.

A3. Guiding principles

Consideration of the reallocation approach and impact on the SRA should have regard to the following guiding principles. These principles were identified in the December 2022 PEC Market Implementation Paper to support stakeholders' consideration of the issues and options, as well as inform the Settlement Residues Committee decision making process.

1. Effectiveness of solution – *does the solution address the problem?*
2. Timeliness of solution – *can the solution be implemented ahead of key PEC phases?*
3. Cost of solution – *is the solution cost efficient to AEMO and industry?*
4. Facilitate inter-regional trade – *will the product be useful for Traders and encourage inter-regional trade?*
5. Maintain system security – *the solution must allow AEMO to maintain system security at all times.*
6. Durability – *is the solution sustainable in during system security actions and in the presence of variable IRSR outcomes?*
7. Predictability and transparency – *does the solution support stakeholder's ability to identify and manage risk and opportunity in SRA trading?*

A4. List of consultation questions

	Category	Questions for consultation
1	Current process	AEMO considers the current process is unsuitable and will restrict efficient dispatch. Are there any additional advantages or disadvantages with the current process identified by stakeholders that could apply in the context of transmission loop flows?
2	Approach	AEMO considers regulatory precedent requires negative residue management be retained for periods where IRSR is in deficit around the loop, that this be automated as far as possible, and limited to $100,000 and any accruing negative residues be allocated to the importing TNSP. For these instances, there would not be any reallocation required. Are there any other approaches to negative residue management AEMO should consider?
3	Approach	In considering the reallocation approach, AEMO considers a sensible method is to allocate negative residues is in proportion the with positive residues on the other interconnectors in the loop. AEMO considers it is preferrable that an interconnection that is negative not receive a proportion of the positive residues. Do stakeholders agree?
4	Approach	Do stakeholders consider these approaches to be reasonably robust, irrespective of whether negative IRSR is deducted from the payouts to SRA unit holders?
5	Approach	Do stakeholders have a different method for the reallocation of negative IRSR that should be considered?
6	Approach	Which option best meets the guiding principles identified in Appendix A3? Are there other options that also meet the guiding principles that should be considered?
7	Approach	Should AEMO propose a method that deducts negative IRSR from the payout to SRA unit holders; or reallocates negative IRSR, in proportion to positive IRSR, directly to consumers in the importing regions?
8	Approach	What, if any, other factors need to be included when considering the payment for negative IRSR?
9	Implementation	The reallocation approach would require updates to AEMO's settlement systems and procedures. What does AEMO need to consider in terms of: • Participant or TNSP market and settlement systems? • Timing of implementation?