Methodology for the calculation of Forward-looking Transmission Loss Factors

Issues paper:

Standard consultation for the National Electricity Market

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Explanatory statement and consultation notice

This consultation paper commences the first stage of the standard rules consultation procedure conducted by AEMO to consider potential improvements to the Forward-Looking Transmission Loss Factors (**FLLF**) methodology[1] (**proposal**) under National Electricity Rules (**NER**) 3.6.1(c), 3.6.2(d), (d1) and (g), 3.6.2A(b) and 3.6.2B(c)(1). The standard rules consultation procedure is described in NER 8.9.2. Many elements of the FLLF methodology are prescribed under the NER, would therefore require an AEMC rule change to be modified and are, in turn, out of scope of this consultation. AEMO describes the scope of consultation in further detail in section 2.4.

The NER require AEMO to calculate, each year, inter-regional loss factor equations and intra-regional loss factors, and to publish the results by 1 April. AEMO has developed the FLLF methodology to set out the process by which these factors are determined. AEMO has prepared this consultation paper to facilitate informed debate and feedback by industry about opportunities to improve the methodology for determining intra-regional loss factors. The paper has broad coverage of the FLLF methodology, but particularly focuses on the following sections of the document:

- *5.3: Controllable network element flow data.*
- *5.4: Generation data.*
- *5.5: Supply-demand balance.*
  - *Minimal extrapolation level configuration.*
  - *Clusters.*

In developing proposals (and ultimately assessing them through later consultation phases) to address the issues identified in this paper, AEMO will seek to adhere to the national electricity objective (NEO). AEMO proposes that simplicity and transparency are added as secondary objectives for this consultation[2].

AEMO invites stakeholders to suggest alternative options where they do not agree that AEMO's proposals would achieve the relevant objectives. AEMO also asks stakeholders to identify any unintended adverse consequences of the proposed changes. Through methodology updates, AEMO is seeking to implement changes to the marginal loss factor (**MLF**) determination process for the period commencing 1 July 2025. To achieve this, AEMO is aiming to publish a final report and amended methodology in late 2024. AEMO also welcomes feedback on other longer-term matters to inform forward planning.

AEMO's proposal to address the issues raised in this consultation paper will require detailed consideration informed by stakeholder feedback. At a high level, AEMO intends that its proposal will update the methodology to reflect the evolution of the National Electricity Market (**NEM**) and utilise AEMO's recently enhanced software capability for calculating MLFs.

The proposal includes updates to:

- The technology groupings in MLF calculations,

[1] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/market-operations/loss-factors-and-regional-boundaries.

[2] Discussed in Section 2.3.

- The processes for accounting for intra-regional constraints, and
- The treatment of new classifications of interconnectors.

AEMO considers that its proposed changes will improve the process accuracy, simplicity and transparency of MLF calculations and will therefore improve both dispatch efficiency and investment signalling. The detailed sections of this consultation paper include more information on the proposal and, to the extent the proposal has been formed, AEMO's reasons for making it.

For the remainder of this document, the term 'issues paper' will generally be used in place of 'consultation paper', and 'MLF methodology' may be used in place of 'FLLF methodology'.

Consultation notice

AEMO is now consulting on this proposal and invites written submissions from interested persons on the issues identified in this paper to mlf_feedback@aemo.com.au by 5:00 pm (Melbourne time) on 2 August 2024.

Submissions may make alternative or additional proposals you consider may better meet the objectives of this consultation and the NEO in section 7 of the National Electricity Law. Please include supporting reasons.

Before making a submission, please read and take note of AEMO's consultation submission guidelines, which can be found at https://aemo.com.au/consultations. Subject to those guidelines, submissions will be published on AEMO's website.

Please identify any parts of your submission that you wish to remain confidential, and explain why. AEMO may still publish that information if it does not consider it to be confidential, but will consult with you before doing so. Material identified as confidential may be given less weight in the decision-making process than material that is published.

Submissions received after the closing date and time will not be valid, and AEMO is not obliged to consider them. Any late submissions should explain the reason for lateness and the detriment to you if AEMO does not consider your submission.

Interested persons can request a meeting with AEMO to discuss any particularly complex, sensitive or confidential matters relating to the proposal. Please refer to NER 8.9.1(k). Meeting requests must be received by the end of the submission period and include reasons for the request. We will try to accommodate reasonable meeting requests but, where appropriate, we may hold joint meetings with other stakeholders or convene a meeting with a broader industry group. Subject to confidentiality restrictions, AEMO will publish a summary of matters discussed at stakeholder meetings.

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1. Stakeholder consultation process

As required by the National Electricity Rules (**NER**) 8.9.2, AEMO is consulting on the Forward-looking Transmission Loss Factor (**FLLF**) methodology, often referred to as the marginal loss factor (**MLF**) methodology, in accordance with the standard rules consultation procedure in NER 8.9.2.

Note that this document uses terms defined in the NER, which are intended to have the same meanings.

AEMO's indicative process and timeline for this consultation are outlined below. Future dates may be adjusted and additional steps may be included if necessary, as the consultation progresses.

Table 1 Indicative consultation timeline

Consultation steps	Dates
Pre-consultation industry workshops to seek feedback for inclusion in issues paper	10 May 2024 24 May 2024
Issues paper (or 'consultation paper') published	5 July 2024
Consultation presentations	TBA
Submissions due on issues paper	2 August 2024
Draft report published	Expected 30 August 2024
Submissions due on draft report	Expected 27 September 2024
Final report published	Expected 25 October 2024

2. Background

2.1. Context for this consultation

MLF determinations are forward-looking, based on forecasts of both consumption and generation. Each type of forecast is prepared separately, resulting in imbalances between consumption and generation. To balance these forecasts, the current MLF calculation methodology contains a process called minimal extrapolation (described in Section 3.3). This methodology was configured at a time when the National Electricity Market (**NEM**) had a less diverse technology mix and less substantial year-on-year variations in capacity than are seen today. These factors have drawn into question whether the existing configuration of the minimal extrapolation logic still leads to reasonable approximations of current and future market dynamics.

Given this context, previous engagement with stakeholders, and a desire for greater software support, AEMO has developed a replacement for the supply and demand balancing engine in TPRICE – the tool historically used to determine MLF outcomes (explained further in Section 2.1.1). This engine allows AEMO's calculation process to address a range of known issues with the MLF methodology targeted through this consultation. Further, unlike its predecessor, the engine is configurable in terms of responding to changes in the future NEM landscape. The new tool could, for example, be configured to reflect different groupings of technologies, or even calculation philosophies other than minimal extrapolation.

AEMO is seeking to review whether the previous configuration of calculation logic is an appropriate enduring approach for balancing supply and demand in the MLF calculation process. This consultation also presents opportunities to update elements of the MLF calculation process. AEMO intends to work alongside stakeholders to design and implement a solution that better reflects the needs of the current and future NEM.

2.1.1. Software context

This section is included to provide background on the software related to MLF calculations:

- From the next calculation cycle, for application in the 2025-26 financial year, supply-demand balancing will be carried out by an application that has been developed in-house expressly for this purpose. The application is called NEMLF.
- The previous balancing engine was contained within software called TPRICE, which was also historically used to carry out the load flow simulation studies required for MLFs. From the next calculation cycle, supply-demand balancing and load flow simulations will be undertaken by separate applications. The former will occur using NEMLF and the latter will be undertaken in the Power System Simulator for Engineering (**PSS®E**) application. PSS®E is industry-standard software and its use should improve process transparency.
- NEMLF is based on linear programming and borrows some concepts from the NEM dispatch engine (**NEMDE**) formulation. One of the key distinctions between the two programs is that NEMDE's dispatch targets cover all generation required to meet consumer demand, whereas NEMLF, as a balancing engine, only makes adjustments to generation so that supply meets demand.

- NEMLF is highly configurable and has advanced capability to account for network limits, including automated implementation of intra-regional transfer limits through the use of distribution factors[3].
- On a separate topic to MLFs, TPRICE remains in use for determination of transmission use of system (**TUOS**) charges.

2.2. NER requirements

The NER require AEMO to calculate, each year, inter-regional loss factor equations and intra-regional loss factors for transmission network connection points, and to publish the results by 1 April. The NER also require AEMO to develop and publish a methodology by which AEMO will determine the annual intra-regional loss factors (commonly referred to as marginal loss factors, or MLFs). The methodology must be consistent with the principles specified in clause 3.6.2(e) of the NER.

AEMO has developed the Forward-Looking Transmission Loss Factors (**FLLF**) methodology to set out the methodology for determining MLFs, and to specify related matters as required under clauses 3.6.1, 3.6.2 and 3.6.2A of the NER.

2.3. Consultation objectives

2.3.1. The national electricity objective (NEO)

Within the specific requirements of the NER applicable to this proposal, AEMO will seek to make a determination that is consistent with the NEO and, where considering options, to select the one best aligned with the NEO.

The NEO is expressed in section 7 of the National Electricity Law as:

> *to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to:*
>
> *(a) price, quality, safety, reliability and security of supply of electricity; and*
>
> *(b) the reliability, safety and security of the national electricity system; and*
>
> *(c) the achievement of targets set by a participating jurisdiction—*
>
> > *(i) for reducing Australia's greenhouse gas emissions; or*
> >
> > *(ii) that are likely to contribute to reducing Australia's greenhouse gas emissions.*

2.3.2. Secondary objectives of consultation

The NEO comprises the primary aim of this consultation and the basis for assessment of the options considered in it. There is also a clear requirement on AEMO to consider the objective of accuracy of MLF calculations, expressed through NER 3.6.2(e)(2) and (2A) and NER 3.6.2A(d)(1).

Based on previous stakeholder feedback, AEMO considers that the following should also be factored into assessment:

[3] Distribution factors will be described in section 3.3.2 and 3.3.3

- Transparency of the MLF calculation process.
- Simplicity of the MLF calculation process.

AEMO considers that incorporating these secondary objectives would enhance the ability of market participants to understand and anticipate MLF outcomes. AEMO notes that it has recently published the first iteration of the Enhanced Locational Information (**ELI**) report[4], which is intended to support decision-making on where projects should locate, and is therefore related to MLFs.

Questions
Do stakeholders agree with the proposed secondary consultation objectives?

2.4. Scope of consultation

AEMO has developed this Issues Paper to encompass the full scope of the discretion it is granted under the NER to change the FLLF methodology. While AEMO has shaped its proposals to be implementable for the 2025-26 MLF determination, AEMO is open to discussion on issues that may require a solution to be implemented in future methodology revisions. AEMO can factor this discussion into forward planning.

Many elements of the FLLF methodology are prescribed under the NER and would therefore require an AEMC rule change to be modified. Any discussion topics related to these elements are, in turn, out of scope of this consultation and would require a separate working group to be addressed. These topics include, but are not limited to, the use of average loss factors instead of marginal loss factors and the duration over which MLFs apply. As an initial step in engaging with industry on these topics, AEMO describes several relevant discussion items in its MLF discussion points register[5] and describes how stakeholders can contact AEMO with further items.

3. Issues, options and proposals for consultation

3.1. Controllable network element flow data

FLLF methodology sections 5.3 and 5.5

3.1.1. Direct current (DC) interconnectors

Issue

Controllable network elements (or DC links) in the NEM can either be regulated assets, or they can be operated by market network service providers (**MNSPs**).

The current methodology considers how DC links are treated in calculations. The methodology explicitly covers the cases of regulated DC links that run in parallel to alternating current (**AC**) interconnectors

[4] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/enhanced-locational-information.

[5] At https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/market-operations/loss-factors-and-regional-boundaries/marginal-loss-factor-forums-2024.

(methodology Section 5.5.3), and MNSP DC links that are not in parallel to AC interconnectors (methodology Section 5.3.1). It currently has no consideration of regulated DC interconnectors that do not have an AC counterpart. Such a case is relevant to APA group's application to convert Basslink from the MNSP approach to the regulated approach. This application is currently being progressed by the Australian Energy Regulator (**AER**). In devising an approach to handle regulated DC interconnectors, there may be opportunities to update the methodology for MNSP DC interconnectors.

Options

1) Status quo – fixed historical DC link flows

The supply-demand balancing process in MLF calculations has historically used flow data largely unchanged from the reference year for MNSP DC links without an AC counterpart. The simplest option available to AEMO in its MLF methodology is to extend this approach to regulated assets.

2) Allow regulated DC link flows to change in the supply-demand balancing process

Allowing regulated DC links to change as part of the supply-demand balancing process may improve the accuracy of MLF calculations. Two options to do this are described below. Please note that these approaches could also apply to MNSP DC links:

a) In relation to Basslink, the Tasmanian region could initially be studied in isolation, with Basslink inserted into Tasmania's minimal extrapolation 'levels' (explained in Section 3.3.1). Basslink flows could then be held fixed while the subsequent step of supply-demand balancing on the mainland is carried out. This option would require relatively simple changes to the configuration of the supply-demand balancing engine.

b) DC links could be treated like other interconnectors within the supply-demand balancing process for the whole NEM. This would create challenges for distribution factor[6] calculations that would need to be resolved through changes to the design of the supply-demand balancing engine. This would be more involved than option (a) and may be challenging to implement in time for the next MLF calculation cycle.

Proposal

Subject to stakeholder feedback, AEMO is keen to develop the options under 2 above. In principle, 2(b) would be most accurate, however, AEMO would need to assess its feasibility before recommending it. In principle, 2(a) would be less accurate than option 2(b), but would still have potential benefits above option 1, and could be the preferred option if 2(b) is challenging to implement. Option 1 can be thought of as a continuation of the status quo. Though it would not yield performance benefits, there may be value in using a known approach with a simple philosophy.

The success of any option 2 approach hinges on considered incorporation of regulated DC interconnectors into the configuration of minimal extrapolation levels. This concept and related consultation questions are included in Section 3.3.1.

Questions
Are stakeholders supportive of AEMO developing options to incorporate regulated DC link flows in the supply-demand balancing process?

[6] Distribution factors will be described in section 3.3.2 and 3.3.3

3.2. Generation data

FLLF Methodology Section 5.4

3.2.1. Committed generation classifications

Issue

The current MLF methodology assumes new generation capacity enters the market on timelines that reflect AEMO's 'generation information' reporting. Specifically, MLF calculations incorporate the full commercial use date (**FCUD**) for projects in its 'committed', 'committed¹' or 'committed*' classifications, which are defined terms in generation information reports[7].

Other AEMO processes also incorporate generation information reporting, but consider projects in a broader range of statuses. For example, the Electricity Statement of Opportunities (ESOO) incorporates 'anticipated' projects, and assumes a FCUD that is offset from the date indicated in generation information reporting according to the later of:

- The first day after the T-1 year for Retailer Reliability Obligation (**RRO**) purposes, or
- One year after the FCUD submitted by the developer[8].

The use of broader project status classifications in other AEMO processes demonstrates the potential for similar measures to be taken in the MLF methodology.

Options

1) Continue the current usage of project status classifications from generation information reporting

This includes the committed, committed¹ and committed* classifications.

2) Expand the usage of project status classifications

This could include more status classifications, time offsets compared to formal FCUD reporting, or both.

Proposal

AEMO recognises that consistency across its processes can be helpful, however it is also mindful that different processes should be tailored to their different purposes. To AEMO's knowledge, its current usage of project status classifications is fit for purpose and, in lieu of feedback to the contrary, its default is retain this usage. AEMO welcomes stakeholder feedback on its current methodology and suggestions for how it could be improved.

Questions
• **Do stakeholders consider there would be benefit in updating the treatment of new generators in the MLF calculation process? If so, why?**

[7] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

[8] Further detail can be found in the 'ESOO and Reliability Forecast Methodology Document', at: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-reliability/nem-electricity-statement-of-opportunities-esoo.

Questions

- **Should the project statuses utilised in MLF calculations be expanded to include 'anticipated' projects? If so, what assumptions around timing should be included for this category?**

3.3. Supply-demand balance

FLLF methodology Section 5.5

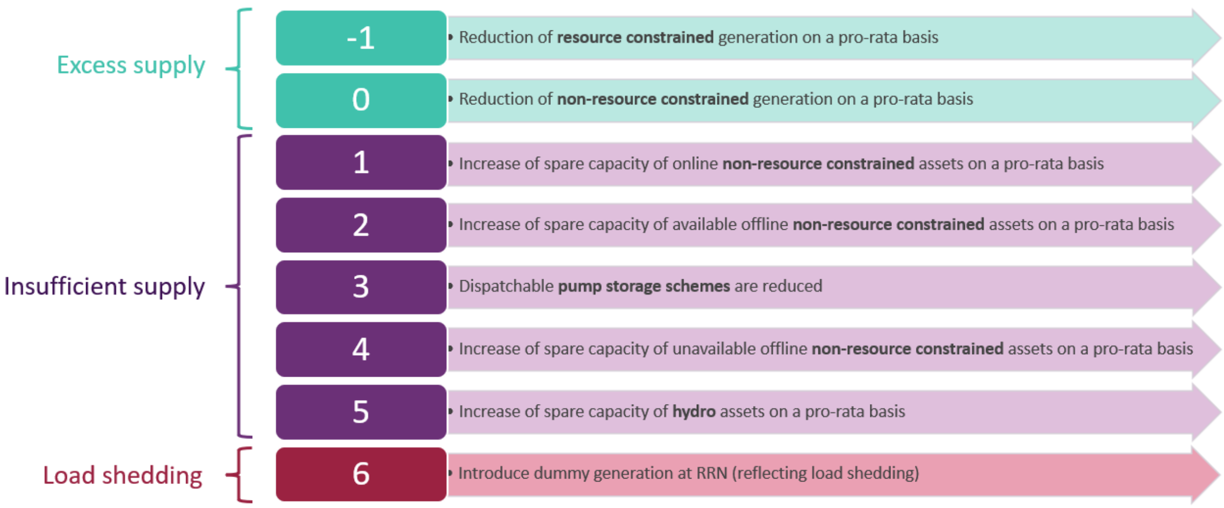
The options and proposals presented throughout this document assume AEMO follows a philosophy of 'minimal extrapolation' for balancing the separately determined forecasts of supply and demand that are inputs to MLF calculations. Minimal extrapolation involves starting with historical supply and demand profiles, augmenting them to reflect things like plant capacity changes and then adjusting generation one grouping or 'level' at a time until supply and demand are matched in aggregate. The specification of these levels is a key topic of this consultation. Discussion of minimal extrapolation compared to other calculation philosophies is provided in Appendix C, including additional consultation questions.

3.3.1. Design of minimal extrapolation levels

Issue

Minimal extrapolation has historically been configured in the MLF calculation in accordance with Figure 1. To illustrate how the diagram works, suppose the projected demand were to exceed supply in a given interval. In this case, the TPRICE engine would increase all generating capacity in level 1 (online non-resource constrained) before increasing capacity in level 2, and so on. This would continue until demand is ultimately met, and adjustments for individual generators at each level would occur in proportion to their capacity in that level. Conversely, to reduce supply in cases where supply exceeds demand, TPRICE would move from level 0 to level -1.

Figure 1 Existing configuration of minimal extrapolation levels



The current configuration of levels in TPRICE:

- Was developed 20 years ago.

- Separates energy-limited generation, non-energy-limited generation and pumps. In this context:
  - Energy limited plant includes thermal generation.
  - Non-energy limited plant groups hydro, wind and solar.
- Models generator technical minimum stable generation limits ('mingen') and allows targets to fall below mingen during ongoing operation. Note that, strictly, TPRICE itself does not consider mingens, but AEMO accounts for mingens through post-processing of TPRICE outputs.
  - In real-world operation, units would only be expected to receive targets below their mingen during start-up or shut-down, and single units at a station can turn off while other units continue operation above mingen.
  - In TPRICE, all units at a given station are indistinguishable and must therefore have the same output. This feature is relevant to cases where a station is the marginal energy provider and its units are partially dispatched[9]. AEMO would generally overwrite instances where the MLF calculation produces results that breach technical limits – for example unit output falls below mingen. However, AEMO may allow calculation outputs with lower-than-actual mingens as this can be equivalent to allowing units to switch off in terms of the overall supply-demand balance. AEMO is not bound to the current approach in the future, as the new supply-demand balancing engine (NEMLF) can account for mingens directly and does not require identical output from all units at a station.

Options

With its new supply-demand balancing engine, AEMO has options to update the configuration of levels in several different ways.

1) Level definitions

The current categories could be expanded to separately consider different technology types or groupings of technology types, for example:

- Thermal peak.
- Thermal baseload.
- Hydro with large storage.
- Variable renewables (run of river hydro, wind, solar).

The same categories do not need to apply to excess supply and excess demand cases in NEMLF and generation could be divided more than current process to reflect concepts like technical and commercial minimum generation levels.

2) Level ordering

NEMLF is not bound to following the existing order of levels, nor is it a requirement that levels in excess supply cases are ordered the same as excess demand cases.

[9] As a side note, this feature of TPRICE is also relevant in the context of dispatch occurring on a 5-minute basis but MLF calculations having a 30-minute resolution. It is possible that a unit starting up, shutting down, cycling on and off, etc., could remain within technical limits but have a 30-minute average generation below mingen. The calculation process accounts for this.

Proposal

AEMO considers that the current levels are no longer fit for purpose and should be updated to account for the technological evolution that has occurred since the configuration of levels in TPRICE. AEMO notes that the historic levels group technologies (for example hydro and solar) with dissimilar behaviour and considers that the number of levels should therefore be expanded. However, AEMO suspects there may be diminishing benefits from implementing increasingly sophisticated configurations of levels, and anticipates that such configurations will be more difficult to consult on and design. Therefore, AEMO proposes that the number of levels should only increase modestly so as to balance simplicity and accuracy.

Conceptually, AEMO considers that a good starting point for levels would be to group technologies with similar market behaviour. It also considers groupings should generally contain substantial megawatt (**MW**) capacity, so as to limit the number of groupings. Ideally, such groupings could be derived from an existing public source to improve process transparency and consultation effort, however AEMO is mindful that any information source also needs to be fit for purpose.

Questions

- **Do stakeholders agree that the current configuration of minimal extrapolation levels needs to be changed?**
- **If so, how should levels be expanded, re-ordered and/or re-defined?**
  - **How should AEMO account for minimum stable generation in minimal extrapolation?**
  - **Where in the hierarchy of levels should AEMO consider regulated DC interconnectors, if at all?**

3.3.2. Cluster resolution

Issue

AEMO's new supply-demand balancing engine (NEMLF) includes functionality to define 'clusters'. These are groups of generators in the same minimal extrapolation level whose output is all adjusted in the same ratio in the balancing process when under the effect of network constraints. For reasons described later in this section and in Appendix D, clusters allow the engine to account for intra-regional constraints but also manage the risk of concentrating output changes onto single generators. Implemented carefully, this should improve the accuracy of predictions compared to the current process, which by default assumes all units in the same level are adjusted together. AEMO will need to devise a process for determining the resolution of clusters, factoring in input received through this consultation.

At one end of the cluster resolution spectrum is the option to aggregate all units of the same level in a given region into a single group in the minimal extrapolation process (that is, the lowest possible number of clusters), meaning they would all be adjusted in the same ratio in the balancing process. This approach is challenged when two units are connected by a line with the potential to have a binding limit. For the reasons described in Appendix D.1, aggregating these units would inhibit the balancing engine's ability to manage such constraints.

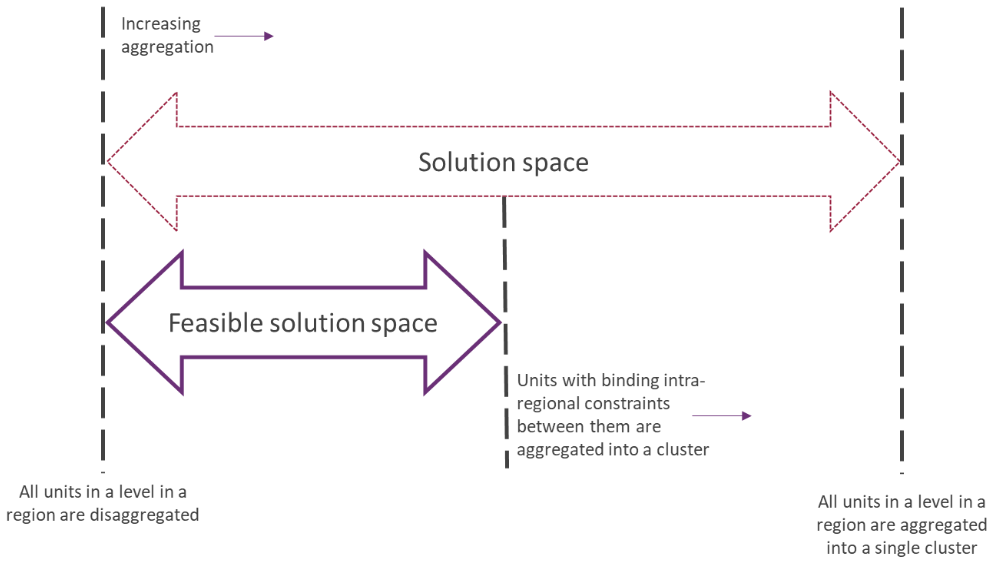
Disaggregating all units is the option at the other end of the cluster resolution spectrum (i.e. the highest possible number of clusters). Under this approach, output adjustments in a given minimal extrapoloation level to manage constraints would occur for the unit with the largest constraint coefficient (referred to as a 'distribution factor' in the context of MLF calculations), then the next largest and so on. As is explained through the example in Appendix D.2, AEMO expects this would increase the optimality of the solution (i.e. how *should* supply be adjusted to manage constraints, given static bids assumed to perfectly reflect costs) but not the accuracy of the solution (i.e. how *would* supply be adjusted to manage constraints). Conceptually, the main reason accuracy may not improve is that complete disaggregation assumes participants would not re-bid given substantial changes in output, which is not correct. The effect of this assumption is softened by introducing clusters, as clusters spread changes in output across many generators, effectively simulating the outcomes if re-bids were to occur.

Options

The new supply-demand balancing engine works by representing the network as pre-defined clusters that are applied to a full year of calculations. Clusters will inevitably have various resolutions (i.e. consisting of various numbers of units), but can ideally reflect a relatively consistent basis by which groups of generators are separated from one another.

NEMDE needs to be able to constrain units to manage any network limits, so AEMO considers that the supply-demand balancing process needs this capability too. Therefore, at a minimum, clusters must be defined such that where two units are connected by a line with the potential to have a binding limit[10], those two units must always be allocated into separate clusters. The design methodology must therefore incorporate an approach that lies on the spectrum between this baseline and complete unit disaggregation. An illustration of the spectrum of feasible options is provided in Figure 2.

Figure 2 Spectrum of feasible options for cluster resolution



[10] Effectively, where two units connected by a single line have positive and negative distribution factors with respect to that line. Appendix D.1 is an example of this.

Proposal

To represent market outcomes as accurately as possible, AEMO would generally seek to avoid clustering together units with large differences in distribution factors. For example, suppose G3 in the diagram in Appendix D.2 had a distribution factor of 0.1 (instead of 0.5 as shown), and this was clustered with G1 which had a factor of 0.9. In practice, G3 may re-bid capacity to a lower price band and this could reduce the tendency for NEMDE to reduce its output. However, this may be less effective than if G3 had a larger distribution factor. If this were the case, grouping these two generators into a cluster would less accurately predict how NEMDE would adjust unit outputs under the influence of network constraints than if the two distribution factors were similar.

AEMO considers that it would not be able to depend on simple numerical thresholds (e.g. difference between largest and smallest distribution factor >0.5) to define cluster boundaries. This is because AEMO would first need to consider unit-level distribution factors to define clusters, and then formulate cluster-level distribution factors (that is, the left-hand size variables are cluster outputs) for use in the supply-demand balancing engine. From there, certain clusters may be excluded from certain constraints (see Section 3.3.3), which would implicitly exclude certain units and therefore change the basis for the initial definition of cluster boundaries. Matters such as the number of times a constraint binds are also worth consideration in the context of a yearly calculation cycle. Ultimately, AEMO may need to apply an iterative process and exercise discretion to determine an appropriate cluster specification.

Questions

- **Do stakeholders agree that AEMO should define clusters that it considers will most accurately predict market outcomes, with regard to factors like:**
  - **Distribution factors in the supply-demand balancing engine (NEMLF)?**
  - **The impact across the calculation year of the chosen cluster definition?**
- **Are there other factors AEMO should consider in defining clusters?**

3.3.3. Representation of clusters in constraints

Issue

There are two features of the methodology (proposed in sections 3.3.1 and 3.3.2) that are designed to spread or ‘socialise’ output adjustements that occur during the supply-demand balancing process across multiple generators.

1) Minimal extrapolation ‘levels’ that group generators by technology type

2) Clusters that group generators of the same level where they have similar impacts on network flows

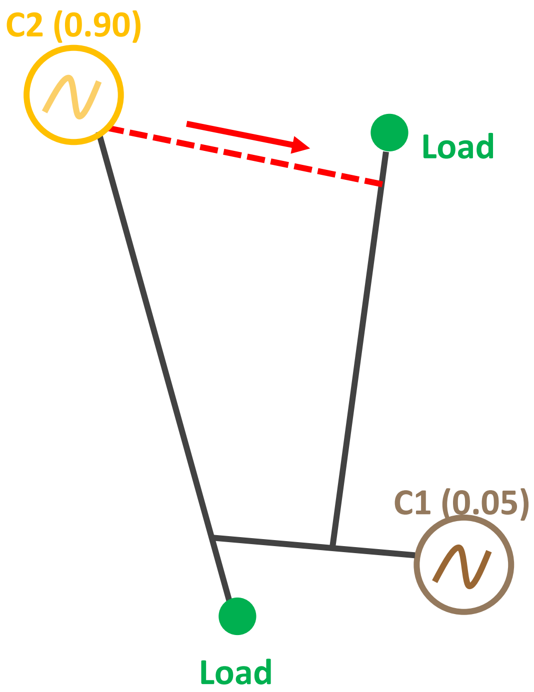
Feature (1) socialises the impact of any output adjustments and feature (2) particularly socialises the impact of output adjustments that manage network constraints. The interaction of these two features can have undesirable side-effects. For example, consider Figure 3 and suppose:

- C1 and C2 are clusters of generators.
- The red line is violating a network constraint.

- C1 and C2 have distribution factors of 0.05 and 0.90 respectively with respect to the violating network constraint.

To manage the violating network constraint, the linear program in the new supply-demand balancing engine needs to reduce output from one or both of the generator clusters. If C1 and C2 were the same type of technology (that is, the same minimal extrapolation level) then the program would prioritise reducing C2 output, as it has the higher distribution factor. However, if C1 was a technology that appeared before C2 in the hierarchy of minimal extrapolation levels, then the engine would first reduce C1's output, even though C2 would have a far greater[11] impact in terms of managing the violating constraint.

Figure 3 Adjusting output of clusters in different levels to manage constraints



The intent of minimal extrapolation is to introduce an order for adjustment that reflects reasonable assumptions about costs and behaviour, not to impose a firm requirement that one technology should be preferred to another even when there is clearly a lower cost alternative (adjusting C2 is likely the lower cost alternative in the example). This issue is potentially exacerbated by the fact that, to achieve a given level of benefit in terms of managing a constraint, a linear program needs to significantly change the output of units with small distribution factors. This can result in substantial differences in output compared to a case with a more realistic sequence of adjustment of cluster output. Completely eliminating these sorts of issues would require either the removal of minimal extrapolation levels or clusters from the methodology. AEMO does not consider this would be desirable, however it notes that these concepts are explored through other areas of this consultation.

[11] 0.9/0.05 = 18 times greater impact from adjusting C2 output than C1 output in terms of managing the violating constraint.

Options

There are options to manage the issue described above that do not involve removing minimal extrapolation levels or clusters from the supply-demand balancing process methodology. The two options described below are not mutually exclusive.

1) Clusters could be removed from constraints if their distribution factors fell below a certain threshold, similar to NEMDE's restriction of constraint coefficients less than 0.07[12]. This could be based on the value of the distribution factor, the difference between the largest and smallest distribution factors, or the ratio between the largest and smallest distribution factors. Note, similar to the options described in Section 3.3.2, discretion or iteration may be required to determine thresholds appropriate for particular circumstances.
2) Generator output can be separated into different levels in the minimal extrapolation hierarchy. Section 3.3.1 proposes this idea as a way to capture differences in market response across different ranges of a unit's output (for example, mingen versus variable output). An additional benefit of splitting generator output across levels is that it limits the magnitude of changes in output that can occur for a given generator cluster. For example, in Figure 3, if only a portion of the C1 output was before C2 in the minimal extrapolation hierarchy, then this would reduce the magnitude of output changes for C1 that would occur before moving to C2, compared to the case where C1 output was in a single level. AEMO invites stakeholders to consider these dynamics in their response to consultation questions on level design in Section 3.3.1.

Proposal

AEMO proposes that option (1) should be further developed in consultation with stakeholders.

AEMO proposes that consideration of option (2) should account for the benefits described both in this section and in Section 3.3.1.

AEMO notes that there are linkages between level design (Section 3.3.1), cluster resolution (Section 3.3.2) and constraint representation (this section). AEMO proposes to account for these linkages as it develops its methodology.

Questions

Questions
Do stakeholders agree that AEMO should consider how clusters with small constraint distribution factors are represented in constraints in the supply-demand balancing engine (NEMLF)?

3.3.4. Handling of storage

Issue

Battery storage accounts for a growing share of NEM generation and load. It is therefore of increasing importance that the supply-demand balancing process accurately accounts for batteries. Batteries are a challenging technology to incorporate into a balancing algorithm that is applied to time intervals in

[12] See Constraint Formulation Guidelines at: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/congestion-information-resource.

isolation. Among other challenges, this is because a process that does not account for inter-temporal links may not respect battery state of charge (**SoC**) limitations.

Options

Arguably to a greater extent than other technologies, batteries in the NEM have complex operating strategies and are utilised in diverse ways across different portfolios. This makes developing heuristics to approximate their behaviour more challenging than for other technologies. Further, given the rapid growth of the sector, any assumptions about behaviour are at risk of becoming outdated relatively quickly. Any option chosen for handling storage in MLF calculations should therefore be monitored with regard to its ongoing suitability. This context is important for the assessment of options such as those described below.

1) <u>Assume battery output does not change compared to historical intervals in the supply-demand balancing process</u>

This option continues the existing approach of assuming no change compared to history and effectively excluding batteries from the minimal extrapolation process. Though this assumption is clearly unrealistic, the option has the benefits of being simple and transparent, and being guaranteed to respect SoC limitations.

2) <u>Include batteries in minimal extrapolation levels dynamically based on SoC</u>

This option would not involve explicitly accounting for SoC limitations, but rather adjusting the position of batteries within the minimal extrapolation hierarchy based on an approximation of SoC. For example, in an excess demand scenario, batteries could be placed in an early position in the hierarchy if SoC was predicted to be high and the battery relatively willing to generate, and the opposite if SoC was predicted to be low. The details of the approximation process and the position in the hierarchy under different conditions would require significant design effort. A further challenge would be designing a process that reasonably captures all batteries.

3) <u>Apply a bespoke battery scheduling algorithm over a forward horizon prior to minimal extrapolation</u>

This option could work by fixing the SoC at a certain time of each day (or other interval), observing the supply-demand balance across the day and assigning weightings (analogous to prices) to different periods of the day that describe the relative willingness of a battery operater to charge or discharge at those times. With this information, battery behaviour could be profiled across the day. Note that this option would likely need to assume an energy arbitrage led strategy for battery operation. Once battery output had been determined under this option, the supply-demand balancing process could occur for other technologies via minimal extrapolation.

Proposal

AEMO considers that options similar to (2) and (3) would introduce significant complexity into the MLF calculation process and would require more time to develop than is available prior to the 2025-26 calculation cycle. AEMO is open to developing (2), (3) or alternative options for later calculation iterations if a rationale is established for moving away from option (1). Otherwise, AEMO's default will be to implement option (1). AEMO is also open to implementing option (1) as an interim measure until further maturity of the storage sector can inform an alternative basis for approximating the behaviour of the battery fleet.

Questions

- **What are stakeholders' views on the merits of the options presented to handle storage in MLF calculations, including when they ought to be implemented?**
- **Are there other options AEMO should consider?**

3.4. Minor and administrative changes

To AEMO's knowledge, there is only a single option to address each of the matters described in this section. The changes to the methodology are included for transparency.

3.4.1. Handling loop flows

FLLF methodology Section 5.7.2

The supply-demand balancing engine (NEMLF) will need to account for loop flows introduced as a result of the commencement of Project Energy Connect (PEC) Stage 2. AEMO will endeavour to match the constraints used to manage loop flows in NEMDE and, though the details continue to be refined, does not forsee any feasibility issues. Given, as a general principle, AEMO will endeavour to represent the network in NEMLF as per NEMDE, then there is nothing specific to call out in the methodology document in relation to loop flows. AEMO intends to remove Section 5.7.2 ('Loop flows') from the MLF methodology document.

3.4.2. Boundary point static loss factors

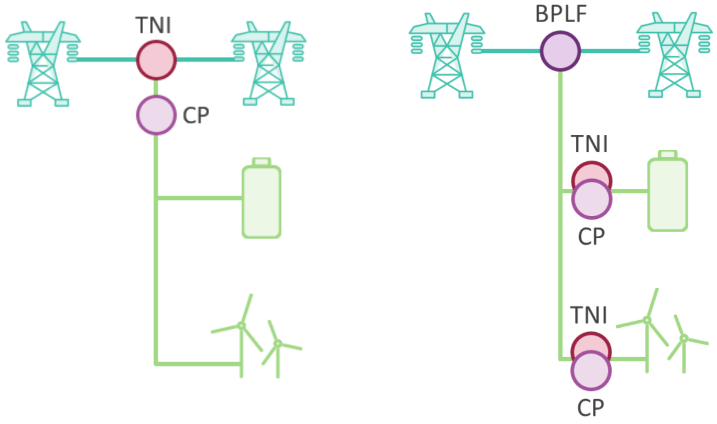
Proposed new FLLF methodology Section 5.8

In 2021, the Australian Energy Market Commission (**AEMC**) made a final determination on its 'connection to dedicated connection assets (**DCAs**)' rule change[13], introducing a framework for designated network assets (**DNAs**). This rule change sought to address issues identified with the DCA framework. The DCA framework, introduced in 2017, was intended to provide a mandated structure for private network assets regarding access and contestability. This included introducing arrangements where transmission node identifiers (**TNIs**) and connection points (**CPs**) were co-located at the boundary between privately funded transmission assets (called DCAs in this case) and the prescribed transmission network. In contrast, the DNA framework allowed for transmission network connection points to be negotiated within the boundaries of the privately funded transmission network (called DNAs in this case).

Figure 4 illustrates the differences between DCAs and DNAs, depicting the shared network in dark green at the top of the diagrams and the privately funded network in light green at the bottom of the diagrams.

[13] See https://www.aemc.gov.au/rule-changes/connection-dedicated-connection-assets.

Figure 4 DCAs (left) versus DNAs (right)



The development of the DNA framework reflected the view that, as DNAs are privately funded assets, intra-regional residues that accrue within them should be allocated to the party/parties funding those assets. To allow for identification of these residues, it was determined that AEMO would as an extension of their obligations pertaining to MLFs be responsible for determining boundary point loss factors (**BPLFs**). BPLFs are effectively an MLF at the boundary of the DNA and upstream assets (typically the shared transmission network).

AEMO plans to include an additional section in the MLF methodology explicitly providing coverage of BPLFs.

3.4.3. Addition of semi-scheduled generation to indicative extrapolation publication

Through ‘pre-consultation workshops’ held prior to the release of this issues paper, AEMO received stakeholder feedback requesting that it release the historical semi-scheduled generation data (indicative extrapolation data) used as an input to the minimal extrapolation calculations. Historically, this has only been released for scheduled generators[14]. AEMO can fulfill this request.

Releasing this data allows participants to verify whether historical dispatch profiles accurately represent anticipated generation patterns. Section 5.5.7 of the MLF methodology describes the process and conditions in which AEMO may use an adjusted generation profile proposed by a generator in lieu of a historical generation profile for the MLF calculation. These processes and conditions are not proposed to change through this methodology consultation.

Questions
Do stakeholders have any comments on the ‘minor and administrative changes’ identified by AEMO?

[14] Examples available under ‘Indicative extrapoloation input data for 2023-24 Marginal Loss Factors’, at https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/market-operations/loss-factors-and-regional-boundaries.

4. Proposal summary

4.1. Description of proposal

As is evident in Section 3, several elements of AEMO's proposal to address the identified issues require further consideration from AEMO, incorporating the feedback, insights and preferences of stakeholders. To the extent the proposal has been formed, AEMO's proposal can be summarised as a set of changes to the MLF methodology that:

- Update the treatment of DC interconnectors in MLF calculations. This measure is necessary due to the expected change in classification of Basslink from a MNSP to a regulated asset, however there are also opportunities for enhancement beyond minimalist approaches that simply account for a new classification.
- Re-configure the minimal extrapolation levels in the supply-demand balancing process from a fuel-constraint basis reflective of a system dominated by thermal generators, to a technology basis reflective of the capacity mix in the current and future NEM.
- Introduce the concept of generation clusters into the handling of constraints in the supply-demand balancing process. Clusters are a streamlined way to account for intra-regional constraints in MLF calculations that allow the degree of socialisation of constraint impact on unit output to be customised.
- Make minor document updates to account for new developments in the market since the MLF methodology was last updated, such as the (future) introduction of inter-regional loops in dispatch and the connection to DCAs rule change.

4.2. How the proposal meets the objectives

AEMO's proposals primarily seek to update the MLF methodology in ways that improve predictions of future dispatch of the market. This should in turn improve the accuracy of estimates within load flow simulations of electrical losses. These losses, volume weighted over a year, are used to derive the MLFs that are used in dispatch. The more accurate the assumptions about marginal losses that are provided as inputs to NEMDE, the greater the efficiency of the central dispatch process and ultimately the better the efficient operation objective within the NEO is met.

AEMO is conscious of the possible tension between process accuracy, which supports efficient NEM operation, and simplicity and transparency, which supports efficient investment in the NEM. The greater the ability for prospective investors to understand AEMO's MLF process and interpret MLF outcomes, the greater the ability to value their future assets and choose appropriate locations for assets within the network.

This methodology identifies several areas of the MLF methodology where it is not clear that a more sophisticated or optimal process would improve process accuracy, and therefore simplicity and transparency should be factored into the appraisal of options. For example, AEMO presents both basic and sophisticated options for the incorporation of DC interconnectors, the design of minimal extrapolation levels, the socialisation of constraint impacts through clusters and the handling of storage in supply-demand balancing. AEMO hopes that stakeholder feedback on these options can help it find an appropriate balance between its various objectives, within the scope afforded to AEMO by the NER.

4.3. Proposed effective date

To be incorporated into MLF calculations that apply to the 2025-26 financial year, methodology changes need to be effective by December 1 2024. This effective date will apply to the majority of changes AEMO has canvassed through this issues paper. There are a small number of changes that may need to be implemented over a longer timeframe, depending on the preferred option for development.

Appendix A. Glossary

Term or acronym	Meaning
AC	alternating current
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
BPLF	boundary point loss factor
cluster	Generators in the same minimal extrapolation level whose output is all adjusted in the same ratio in the balancing process when under the effect of a network constraint.
CP	connection point
DC	direct current
DF	distribution factor. For a given line and a given generator at a network node, the distribution factor is the change in flow across the line when generation at the node is increased by 1MW.
ESOO	Electricity Statement of Opportunities
FCUD	Full commercial use date. This is a field in AEMO's generation information publications.
FLLF	forward-looking transmission loss factor
ISP	Integrated System Plan
mingen	generator technical minimum output
minimal extrapolation	A method for balancing supply and demand where generation output in defined groupings or 'levels' is adjusted in the same ratio, from the starting point of historical output. The method gradually moves through levels in a defined order until supply and demand are matched in aggregate.
MLF	marginal loss factor
MNSP	market network service provider
MW	megawatt
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine
NEMLF	The new supply-demand balancing engine used for MLF calculations in the NEM.
NEO	National Electricity Objective
NER	National Electricity Rules
RRO	Retailer Reliability Obligation
SoC	state of charge
SRMC	short run marginal cost
TNI	transmission node identifier

Appendix B. Consultation questions

Section	Questions
2.3.2	• Do stakeholders agree with the proposed secondary consultation objectives?
3.1.1	• Are stakeholders supportive of AEMO developing options to incorporate regulated DC link flows in the supply-demand balancing process?
3.2.1	• Do stakeholders consider there would be benefit in updating the treatment of new generators in the MLF calculation process? If so, why? • Should the project statuses utilised in MLF calculations be expanded to include 'anticipated' projects? If so, what assumptions around timing should be included for this category?
3.3.1	• Do stakeholders agree that the current configuration of minimal extrapolation levels needs to be changed? • If so, how should levels be expanded, re-ordered and/or re-defined? – How should AEMO account for minimum stable generation in minimal extrapolation? – Where in the hierarchy of levels should AEMO consider regulated DC interconnectors, if at all?
3.3.2	• Do stakeholders agree that AEMO should define clusters that it considers will most accurately predict market outcomes, with regard to factors like: – Distribution factors in the supply-demand balancing engine (NEMLF)? – The impact across the calculation year of the chosen cluster definition? • Are there other factors AEMO should consider in defining clusters?
3.3.3	• Do stakeholders agree that AEMO should consider how clusters with small constraint distribution factors are represented in constraints in the supply-demand balancing engine (NEMLF)?
3.3.4	• What are stakeholders' views on the merits of the options presented to handle storage in MLF calculations, including when they ought to be implemented? • Are there other options AEMO should consider?
3.4.3	• Do stakeholders have any comments on the 'minor changes' identified by AEMO?
Appendix C	• Are there approaches for supply-demand balancing other than minimal extrapolation for which AEMO should consider feasibility? If so, can stakeholders explain how the alternative approach would improve the MLF calculation? • Are stakeholders open to discussing the high-level approach for projecting supply and demand in a forum where NER changes are in scope?

Appendix C. Calculation philosophy

Minimal extrapolation versus alternative calculation philosophies

NER 3.6.2A(d) establishes that AEMO should use historical data as the starting point for MLF calculations. AEMO is only allowed to *model* supply and demand under the NER to the extent of adjusting historical profiles. These adjustments are forecast changes to supply and demand between the reference year and the target year and, subsequently, adjustments that ensure generation and load are in balance. NER requirements effectively exclude approaches that model full profiles of supply and demand as is done for AEMO processes like the Integrated System Plan (**ISP**) and Electricity Statement of Oppprotunities (**ESOO**).

However, high-level approaches other than the progression through 'levels' as described in this document may still be in scope for supply-demand balancing under the current rules. AEMO considered such approaches in preparation for this consultation but could not identify another approach that was simultaneously feasible for the next yearly iteration of MLF calculations and compliant with the NER. Long-lead time approaches do not *need* to be excluded from this consultation, however AEMO proposes they could be better interrogated in a different forum with more appropriate timelines (see bottom of appendix).

One area of alternative approaches considered by AEMO was using bids as inputs to the balancing engine (NEMLF). Bids could be based on historical data, game-theory driven assumptions or short-run marginal costs (**SRMC**) as per other AEMO processes. A limitation of borrowing assumptions such as MLFs from other AEMO processes and applying them to MLF calculations is that processes are developed in specific contexts, and existing AEMO processes often focus on aggregate outcomes rather than individual units. Bid-based approaches to supply-demand balancing see generation adjustments within NEMLF become very site-specific. This may occur in ways that do not reflect actual market dynamics. For example, if SRMC-based bidding were used:

- In cases where supply exceeds demand and generation needs to be adjusted downwards, a generator would always be preferred for adjustment over another if it had an incrementally higher SRMC than another, and this could lead to dramatically different MLF outcomes for very similar units. In practice, bids vary due to a range of factors, participants re-bid in response to changes in targets and other dynamics play out that would likely see similar units 'share' the reductions in output the balancing engine requires over the course of a year.
- There are many units within the NEM for which costs are a poor indicator of their commitment and output, and this can instead be explained in the context of their broader portfolio. AEMO acknowledges that the process of moving through 'levels' can also struggle to account for these cases, however the configuration of levels at least provides a design lever to manage the implications.

In principle, issues like those described above could be addressed by capturing assumptions about operating decisions for specific NEM generators and departing from bid-based output projections in specific circumstances. Developing these assumptions would involve a high degree of subjectivity and require a large amount of consultation. AEMO considers that consulting with every NEM generator subject to an MLF would be unworkable, so would be inclined to consult with stakeholders to develop heuristics for the treatment of certain types of plant (notably, this approach has similarities to designing minimal extrapolation levels). In developing heuristics, AEMO would seek to avoid incorporating bespoke and commercially sensitive assumptions for particular generators, as these would make the calculation harder for stakeholders to replicate and could also make it more opaque. Avoiding such assumptions may reduce accuracy, so this trade-off would need to be considered.

For completeness, though AEMO considers that developing a bid-based approach to supply-demand balancing would require that the challenges described above are addressed, it is not closed to the idea. For the awareness of stakeholders, AEMO notes that implementing a bid-based approach would be a substantial process update that would be challenging to implement in time for its next MLF calculation iteration applying to the 2025-26 financial year. Therefore, though AEMO invites industry feedback on the calculation philosophy through this consultation, it is also open to exploring these ideas with stakeholders in a forum where changes to the regulatory framework are in scope. In such a forum, the proposal could be considered more fulsomely in conjunction with related questions such as whether bid-based modelling should apply to the complete generation profile rather than only the balance of supply needed to meet demand. AEMO is in the initial phases of establishing such a forum, as outlined in AEMO's MLF discussion points register[15].

Questions

- **Are there approaches for supply-demand balancing other than minimal extrapolation for which AEMO should consider feasibility? If so, can stakeholders explain how the alternative approach would improve the MLF calculation?**
- **Are stakeholders open to discussing the high-level approach for projecting supply and demand in a forum where NER changes are in scope?**

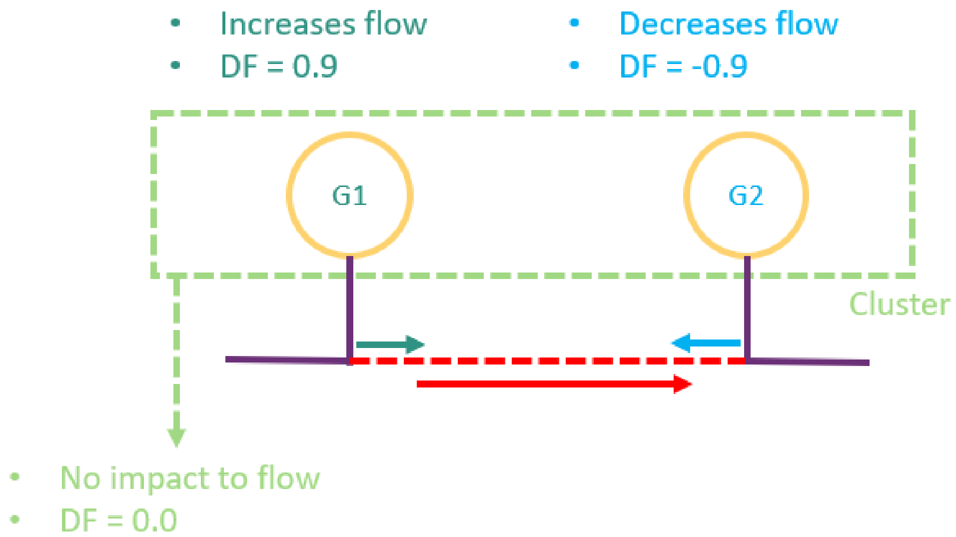
[15] At https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/market-operations/loss-factors-and-regional-boundaries/marginal-loss-factor-forums-2024.

Appendix D. Clusters

D.1 Clusters and intra-regional constraints

In Figure 5 below, suppose the flow on the red line needs to be limited in the direction of the red arrow. Two identical generators both have the same distribution factor with respect to a the transmission line (that is, the same change in line flow given a 1 MW increase in output), however the resultant flow occurs in opposite directions for each generator. Since all units in a cluster are adjusted pro-rata in the supply-demand balancing process, if these two units were aggregated, they could not be used to manage a limit on the relevant transmission line. This outcome is not reflective of the NEM in practice, where NEMDE could manage the line constraint.

Figure 5 Cluster aggregating units separated by an intra-regional constraint



D.2 Clusters and constraint impact socialisation

In Figure 6 below, suppose a line line connecting G1 and G3 to G2 needs to be limited in the direction of the red arrow. Without aggregation, the balancing engine (NEMLF) would decrease G1 all the way to 0MW (if this extent of reduction were needed, ignoring any mingen) before starting to decrease G3. However, in practice, G1 may re-bid to prevent such a degree of reduction, or it may be constrained by its ramp rates[16] and unable to reduce its output to the extent NEMLF suggests. Therefore, a less 'optimal' solution where G1 and G3 are aggregated into a cluster and reduced pro-rata may better reflect actual outcomes, or at least the average of actual outcomes over time. Two notable observations about aggregating G1 and G3 in NEMLF are:

- NEMLF would require more total curtailment to achieve the required reduction in line flows than simply reducing G1. This is because the G1+G3 cluster has a lower distribution factor with respect to the constrained line than G1 (for example 0.65 vs 0.9). This is why clustering could be considered less optimal than a disaggregated approach.

[16] Ramping constraints would only be applicable to certain types of generators.

- Any subsequent impact of curtailment on MLFs is shared between the two generators. This may reduce the volatility in MLF outcomes compared to the 'winner takes all' approach of disaggregating G1 and G3.

Figure 6 Cluster socialising the impact of an intra-regional constraint