FORWARD-LOOKING TRANSMISSION LOSS FACTORS – CONSULTATION

ISSUES PAPER

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EXECUTIVE SUMMARY

The publication of this Issues Paper commences the first stage of the Rules consultation process conducted by AEMO to consider potential improvements to the Forward-Looking Transmission Loss Factors (FLLF) methodology under Rules 3.6.1(c), 3.6.2(d), (d1) and (g), and 3.6.2A(b) the National Electricity Rules (NER).

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 Issues Paper to facilitate informed debate and feedback by industry about opportunities to improve the methodology for determining intra-regional loss factors, commonly referred to as marginal loss factors (MLFs).

This Issues Paper focuses on the following key areas of the methodology:

- Load forecast data.
- Controllable network element flow data.
- Generator data.
- Supply demand balance.
- Publication.
- Unexpected and unusual system conditions.

This Issues Paper also raises three other areas for consideration, but AEMO recognises changes to address these are likely to extend beyond the current methodology consultation due to limitations in the current NER framework or the need for more detailed analysis:

- Network data.
- Intra-regional static loss factors.
- Inter-regional loss factor equations.

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.

The primary objective of the consultation is to consider appropriate changes to the FLLF methodology that can be incorporated into AEMO's process for the determination of MLFs for the period commencing 1 July 2021. To achieve this, AEMO is aiming to publish a final report and amended methodology in December 2020. AEMO also welcomes feedback on other longer-term matters to inform forward planning.

Stakeholders are invited to submit written responses on the issues and questions identified in this paper by 5.00 pm (Melbourne time) on 25 September 2020, in accordance with the Notice of First Stage of Consultation published with this paper.

CONTENTS

1. STAKEHOLDER CONSULTATION PROCESS

As required by the National Electricity Rules (NER), AEMO is consulting on the methodology for Forward-Looking Transmission Loss Factors (FLLF) in accordance with the Rules consultation process in rule 8.9 of the NER.

Note that there is a glossary of terms used in this Issues Paper at Appendix A.

AEMO's indicative timeline for this consultation is outlined below. Dates may be adjusted depending on the number and complexity of issues raised in submissions and any meetings with stakeholders.

Deliverable	Indicative date
Issues Paper published	20 August 2020
Submissions due on Issues Paper	25 September 2020
Draft Report published	26 October 2020
Submissions due on Draft Report	23 November 2020
Final Report published	21 December 2020

Prior to the submissions due date, stakeholders can request a meeting with AEMO to discuss the issues and proposed changes raised in this Issues Paper. During the consultation process AEMO also intends to hold a briefing session for interested parties on the matters raised in this Issues Paper.

NEM registered participants and other interested parties are invited to submit written responses on the questions identified in this Issues Paper and any other aspect of the FLLF methodology. Stakeholders are requested to include reasons for their responses and (if applicable), details of any alternative options they consider may better achieve the relevant objectives. Submissions must be made in accordance with the Notice of First Stage of Consultation published with this paper.

2. BACKGROUND

2.1. 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 FLLF methodology to set out the methodology for determining MLFs, and to specify related matters as required under in clauses 3.6.1, 3.6.2 and 3.6.2A of the NER.

2.2. Role of marginal loss factors

Electrical energy losses occur due to the transfer of electricity through a network. The NER separates losses into two components:

- Inter-regional losses, which are due to a notional transfer of electricity from the regional reference node (RRN) in one region to the RRN in an adjacent region.
- Intra-regional losses, which are due to the transfer of electricity between an RRN and transmission network connection points in the same region.

Loss factors describe the marginal electrical energy losses associated with either inter-regional losses or intra-regional losses. They are both used in the central dispatch process to adjust the price of electricity at RRNs and connection points.

AEMO uses marginal costs as the basis for setting electricity prices in accordance with the NER. The accounting for transmission electrical losses involves expanding this method to electricity generation and consumption at different locations.

Inter-regional loss factors are dynamic, determined by equations that calculate the losses between regions. Depending on region flows and demands, the inter-regional losses also adjust generating plant prices in determining the dispatch order of generation to meet demand.

Intra-regional loss factors are static, and are either a single value (applying to both flow directions) or dual values (i.e. separate values for each flow direction) for each transmission connection point that is a volume-weighted average of marginal electrical energy losses over a financial year.

2.3. Context for this consultation

In recent years, supply and demand patterns in the NEM have been changing at an increasing rate, driven by new technology and a changing generation mix. This has led to large year-on-year changes in MLFs that applied between the 2017-18 and 2019-20 financial years calculated under the current methodology, particularly in areas of high renewable penetration that are electrically weak and remote from load centres. In the most recent MLF determination for the 2020-21 financial year, AEMO also identified that the increasing prevalence of intra-regional constraints can have a material impact on projected power system flows and MLFs.

In addition to the changing power system dynamics, the Australian Energy Market Commission (AEMC) recently made a final rule determination on Transmission Loss Factors[1], which incorporates a number of minor amendments to the framework for loss factors.

[1] https://www.aemc.gov.au/rule-changes/transmission-loss-factors

AEMO held three stakeholder workshops in June 2020 to seek input on issues and opportunities for improvement to the FLLF methodology. This focused on the following areas:

- **Methodology clarification** – clarifying the methodology to align with current operational practices.
- **Rule change** – changes to give effect to the AEMC's final determination on Transmission Loss Factors.
- **Short-term methodology improvements** – identifying any areas of improvement that can be incorporated into the methodology in the short term.
- **Longer-term methodology issues** – issues with the methodology and/or the Rules framework that cannot be addressed in the short term, as they require significant effort to investigate, are likely to involve more complex changes to AEMO systems, and/or changes to the NER.

This Issues Paper will primarily focus on issues in the first three areas, however several longer-term issues have been identified as other matters in Section 4 of this document, and AEMO welcomes feedback on any of these matters.

3. ISSUES FOR DISCUSSION

This section discusses a range of issues identified during stakeholder workshops. Each issue has been grouped into the following areas, based on the aspect of the FLLF methodology to which they relate:

- Load forecast data.
- Controllable network element flow data.
- Generator data.
- Supply demand balance.
- Publication.
- Unexpected and unusual system conditions.

Under each issue AEMO has summarised one or more questions to assist stakeholders in providing feedback, but AEMO welcomes any other feedback that may be relevant or helpful.

3.1. Load forecast data

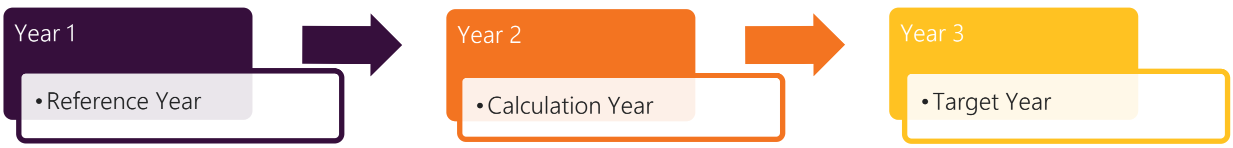
Load forecast data represents the electricity demand that is forecast for the target year as a basis for determining network flows. One issue has been identified with respect to load forecast data.

3.1.1. Reference data

The FLLF methodology currently prescribes that load forecasts for each connection point are to be based on historical data from the reference year, where the reference year is defined in the methodology as the previous financial year (1 July to 30 June) in which historical data is to be used as an input to the loss factor calculation; for example, Target Year is 2015-16 and Reference Year is 2013-14.

The current MLF process occurs over a three-year cycle, as shown in the figure below:

Figure 1 High-level timeline for determining MLFs



Issue summary

As a result of the three-year cycle, historical load data used as a foundation for the MLF study will be up to 21 months old (publication occurs by 1 April each year) by the time the final MLFs are published. Given the dynamic nature of the National Electricity Market (NEM) in recent times, questions have arisen as to the suitability of this data and whether using more recent data would result in MLFs that better reflect the target year.

Key considerations

AEMO has several systems in place to obtain historical load data from the reference year and to prepare the forecasts for the target year.

Some of the underlying processes and systems for load forecasting are not exclusive to MLF calculation, and are used for a number of AEMO planning functions (for example in preparation of the Integrated System Plan (ISP) and Electricity Statement of Opportunities (ESOO)). As these activities are also undertaken on a financial year basis, the underlying processes and systems have been designed with both inputs and outputs that are based on a financial year.

If more recent historical data were required as an input into the MLF process, this alignment of workstreams would be fragmented, which would in turn result in a much more resource-intensive process to prepare load forecasts specifically for MLF studies. Existing processes and systems would also need to be replicated and/or modified to allow for a different definition of the reference year.

A further consideration is the existing workload between obtaining the historical data and the completion of the final MLF study. This workload is a limiting factor on the time the reference year may be brought forward and AEMO anticipates at most an additional three months may be viable.

In light of these cost and change risk impacts, there would need to be a demonstrated material benefit in using later reference data for MLFs. While AEMO appreciates there would generally be a theoretical benefit in using more up-to-date data, it is not clear how these benefits would lead to a material and sustained improvement in MLFs overall.

Questions

- Is there a sustained material benefit in revising the definition of reference year to incorporate more recent data?

3.2. Controllable network element flow data

Controllable network element flow data relates to the way in which controllable network elements, typically direct current (DC) interconnectors, are modelled in MLF studies. One issue has been identified with respect to controllable network element flow data.

3.2.1. MNSP rule change implementation

Issue summary

The current FLLF methodology prescribes that interconnectors operated as market network service providers (MNSPs) are to be treated as invariant; this was historically also prescribed by the NER. There is currently only one MNSP in the NEM, being Basslink which provides an interconnection between Victoria and Tasmania.

When calculating the supply-demand balance, Basslink flow may need to be manually pre-adjusted (from historical values) in scenarios where Tasmania has a supply shortage, based on the principle reflected in clause 5.9 of the current methodology. However, in these supply shortage scenarios Basslink is is not further varied during subsequent steps in the MLF calculation process.

As a result of Basslink being treated as invariant (apart from the above exception), supply and demand balancing outcomes for the mainland and Tasmania are decoupled and the NEM supply and demand balancing outcomes are not considered as a whole.

Key considerations

The current methodology does not allow for inclusion of a DC interconnector which is not parallel to an alternating current (AC) interconnector within the MLF calculation process.

AEMO has investigated potential options relating to the future treatment of Basslink in managing supply/demand balance and has identified the following options:

- Retain existing process of only adjusting Basslink during periods of shortfall in Tasmania.
  - As a consequence, Basslink would generally be considered invariant. It would be recommended however that a specific clause be introduced to cover Basslink treatment during periods of shortfall in Tasmania, reducing reliance on the high level principles in clause 5.9.
- Make Basslink a dispatchable element.
  - After investigation, AEMO has identified a method that would allow Basslink to operate in a similar manner to a thermal generator in terms of supply and demand balance.
  - By modelling Basslink as a series of loads and generators, Basslink would be adjusted in line with thermal generation (at the same level in the supply and demand balancing hierarchy).
- Model Basslink as an AC equivalent line in the current MLF engine.
  - The concept of modelling Basslink as an AC line has been considered. However, given the nature of the relationship between losses (not solely driven by I^2R relationship) and flows on Basslink, an AC line equivalent does not appear to be appropriate given the simplicity and potential value of other options. In addition, the inclusion of a second DC interconnector between Victoria and Tasmania (such as the proposed Marinus Link) would prove problematic if the path taken was not directly parallel to Basslink.

Questions

- Is there a material benefit in incorporating Basslink into the supply and demand balancing process, and if so, should the historical flows from the reference year be used as an initial level of operation?
- Can stakeholders identify any additional considerations/alternatives for the inclusion of Basslink into the supply and demand balancing process?

3.3. Generator data

Generator data represents the electricity supply that is forecast for the target year as a basis for determining network flows. Two issues have been identified with respect to generator data.

3.3.1. Generator capacities

Issue summary

The current methodology prescribes that generating unit capacities are to be derived from the ESOO[2]; for this purpose AEMO uses the Generation Information[3] page to source generator capacities.

Historically the only summer capacities published on the Generation Information page were based on a 10% probability of exceedance (POE), and as a result the summer capacities for generators are often substantially below their rated capability. The MLF process incorporates two capacities for each generating unit, a summer and a winter capacity. Summer refers to the period from 1 November to 31 March and winter refers to the period from 1 May to 31 October.

[2] 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

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

For MLF purposes, these capacities are then applied to the relevant seasons (as noted above). This can lead to generators being constrained to an output level well below what could reasonably be expected for the period between 1 November and 31 March.

Key considerations

The Generation Information page has recently been amended to include an additional set of capacities which are referred to as typical summer capacities. The reference temperatures for both the existing summer capacities and the typical summer capacities can be seen in the table below.

Table 1 Reference temperatures for typical summer capacities

Region	Summer capacity (°C)	Typical summer capacity (°C)
QLD	37	32
NSW	42	32
VIC	41	32
SA	43	35
TAS	7.7	N/A

While still reflective of reductions in capacity under warm conditions, the typical summer capacities are likely to be more appropriate for the purpose of setting the upper limit for generators for the period 1 November to 31 March.

Questions

- Do stakeholders see merit in the use of typical summer capacities as an input to the MLF process?

3.3.2. New generation profiles

Issue summary

The current FLLF methodology prescribes that generation profiles for new generating units are to be produced by scaling of the historical reference year data of similar technology generation. For wind and hydro generators, the relevant proponent is requested to provide a profile, which AEMO will then review for suitability. There are no references to solar or battery technologies in the methodology.

The current methodology assumes the output of generators prior to their commercial operation date is zero (for non-wind/hydro generation). Given the nature of commissioning new wind and solar generators, excluding output during commissioning activities is likely to lead produce MLFs that are less representative of actual power flows.

When creating an output profile from an existing generator of a similar technology, the outcome may not be a reasonable approximation of the new generator's output. This is especially true for thermal generation, where there is a trend towards a larger number of smaller generating unit rather than the traditional fewer yet larger generators.

The processes for creating profiles for new generators have historically been aligned with the Market Modelling Methodologies document[4], which outlines the information sources and models used for forecasting and planning across AEMO's key publications including the Electricity Statement of Opportunities (ESOO). However over time the Market Modelling Methodologies ve been revised and as such the processes are no longer in alignment.

Key considerations

For its determination of the 2020-21 MLFs, AEMO adopted a different process of producing generation profiles for both wind and solar generators, to ensure the profiles were consistent with historical data in the reference year. These generation profiles were then provided to the relevant proponent for review. AEMO considered feedback and made revisions to accommodate reasonable concerns.

For a solar generation reference year, solar irradiance data is sourced from the Bureau of Meteorology (BOM). This is then used as an input to the System Advisor Model[5] (SAM) from the National Renewable Energy Laboratory to construct the profile. Within SAM, additional considerations are made for both wind speeds and air temperatures which are used to consider the thermal derating of panels. Mesoscale wind data and BOM temperature data is used for the thermal derating. Additional considerations are also made for different forms of tracking (such as fixed or single axis).

For a wind generation reference year, wind speed is sourced from the DNV-GL mesoscale data, which has a granularity of 5 km. A power curve (dependent on turbine size) is then used to construct the profile.

For both wind and solar, AEMO has identified generic hold points to reflect commissioning activities prior to the anticipated commercial operation date (from the generation information page). These generic commissioning profiles are based on internal feedback from AEMO teams directly involved in commissioning of new generators based on their observations. For both wind and solar, the reductions are based on capacity and hence the profile is scaled and not capped, representing partial availability (partial inverter or turbine availability).

The current generic hold points for wind and solar are:

- Wind Generic Commissioning Profile.
  - Linear ramp of capacity for nine months.
- Solar Generic Commissioning Profile.
  - One-third capacity for four weeks.
  - Two-thirds capacity for four weeks.
  - Full capacity thereafter.

For new thermal generators, hydro generators and storage (batteries and pumped hydro), forecasting is difficult, as operation is largely driven by commercial interests and/or weather conditions (rainfall for hydro) which are likely to be dissimilar for different proponents and projects. An example is the operation of battery storage in the NEM, where historical behaviour has been observed as vastly different depending on the commercial drivers of the proponent responsible for the battery. For thermal, hydro generators and storage, AEMO considers it more appropriate to obtain forecast profiles from the relevant proponent.

In all scenarios, the relevant proponent will either be provided with a generation profile for review or will provide AEMO with a generation profile for review. Where proponents provide AEMO with advice, or a generation profile is provided by a proponent, AEMO will perform an assessment to ensure the information provided is suitable.

[4] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/Market-Modelling-Methodology-Paper.pdf

[5] Further information on the System Advisor Model can be found at https://sam.nrel.gov/

Questions

- Do stakeholders see merit in the approach of AEMO producing generation profiles internally and the inclusion of commissioning activities within the profiles?
- Can stakeholders identify any additional considerations/alternatives?

3.4. Supply demand balance

Supply demand balance represents the process by which electricity demand and supply are matched (taking into account electrical losses) in each 30-minute period for which MLFs are derived. Five issues have been identified with respect to supply demand balance.

3.4.1. Minimum stable operation levels of thermal plant

Issue summary

Thermal generators have limitations when operating at lower levels, primarily the result of increased vibration and wear (increased moisture content at lower steam temperature) at lower levels of load. For larger generators; the range for stable operation can be relatively small compared to the total capacity.

The current methodology for the balancing of supply and demand in the MLF process does not contain a mechanism to ensure thermal plant are operating within this stable range, and with future increases in semi-scheduled generation, thermal generation output may be reduced to levels below the minimum stable operation levels.

Key considerations

AEMO has investigated the capability of the current MLF engine to allow for thermal generators to have capacity split into varying levels of 'firmness', the capacity being split In such a way that generation outcomes for thermal generators must be within the safe operational range of the thermal generator (between the minimum stable level and the maximum capacity with consideration made for auxiliary load).

Investigations have ascertained that the current MLF engine does not have the capability to enforce minimum stable levels of generation. As such, any process to manage this would need to be performed outside the engine.

AEMO proposes that a process be developed outside the engine where supply and demand balancing outcomes are reviewed, and adjustments and supply and demand balancing re-runs are performed where thermal generators are observed operating below their minimum stable operation level.

A potential source of minimum stable generation levels that has been identified is the Input and Assumptions workbook[6] published as a supporting document to the ESOO. Using these values would align with other MLF processes that also use publications that support the ESOO as inputs to the MLF process, namely generator capacities (sourced from Generation Information page).

[6] The 2019 Input and Assumptions workbook can be found at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/inputs-assumptions-methodologies/2019/2019-input-and-assumptions-workbook-v1-3-dec-19.xlsx?la=en

Questions

- Can stakeholders identify any additional sources for identifying the stable minimum generation levels, and do stakeholders have any considerations/alternative suggestion as to how stable minimum generation levels may be managed?

3.4.2. Minimal extrapolation theory

Issue summary

The FLLF methodology and associated tools were designed at a time where variations in year-on-year generation capacities were largely static, and expected to remain so. By contrast, in recent years large increases of semi-scheduled capacity have been observed in remote areas of the grid.

As such, the minimal extrapolation theory used to balance generation and load is simple in design and not well suited to periods where the forecast generation growth far exceeds any forecast growth in load.

Key considerations

As any revision to the supply and demand balancing process will require a revised MLF engine, or the development of a separate engine, AEMO does not anticipate that a viable alternative could be identified and implemented for the 2021-22 MLF study.

AEMO is currently exploring options for the eventual partial or full replacement of the current MLF engine (TPRICE), and wishes to canvas stakeholder views on what a more suitable supply and demand balancing process could look like. Potential options for management of supply and demand balance include:

- Retain minimal extrapolation theory but expand on categories to ensure a more accurate reflection of real outcomes.
  - An expanded minimal extrapolation theory would allow stakeholders to replicate the supply and demand balancing process used by AEMO with relative ease. Additionally, given the relative simplicity of the minimal extrapolation theory, the supply and demand balancing process can be completed in a reasonable time frame.
- Move to a more complex system for the supply and demand balancing process, for example using short run marginal costs (SRMC).

  Moving to a more elaborate supply and demand balancing process may produce more representative MLF outcomes. Using the SRMC of generators to inform supply and demand balancing outcomes would likely result in supply and demand balancing outcomes that are better aligned with real outcomes than the minimal extrapolation theory. However, a more elaborate supply and demand balancing process would make it more difficult for stakeholders to replicate, and may also materially increase the time required to perform MLF studies.

Questions

- Do stakeholders see merit in retaining the existing minimal extrapolation theory and if so, should it be expanded?
- What alternatives to minimal extrapolation theory do stakeholders consider suitable?

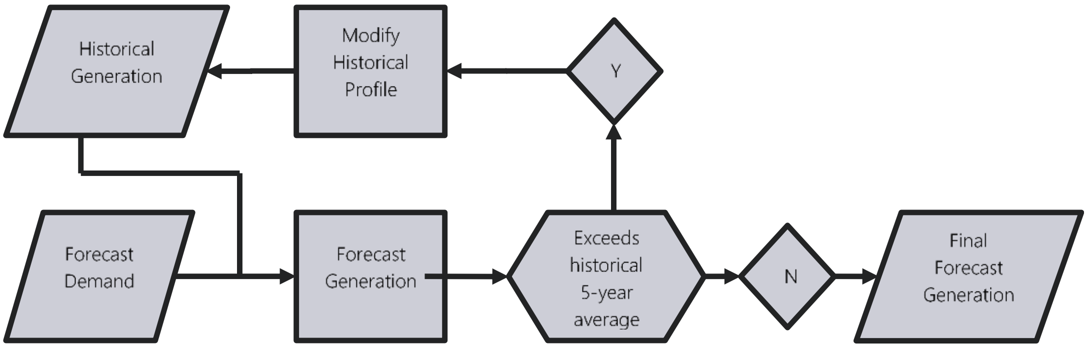
3.4.3. Extrapolation capping

Issue summary

In scenarios where demand is forecast to grow above the increase in generation for the target year, or the exit of a large generator results in the historical generation falling well below the forecast demand, the supply and demand balancing outcome will be subject to a capping process. This occurred for the retirement of Hazelwood Power Station. Going forward, capping or an equivalent process will be necessary to reflect the impact of other large generator retirements.

The existing capping process is shown at a high level in the flowchart below,

Figure 2 Extrapolation capping process



This process is used to limit the forecast generation based on historical outcomes. A buffer may also be applied where the generation outcome after initial capping is insufficient to meet demand.

In addition to the capping process, supply and demand balancing outcomes are published annually to allow proponents to review the outcomes for their assets and provide feedback. Where feedback suggests changes based on physical limitations which are verifiable, AEMO will revise the supply and demand balancing outcome for the relevant assets.

The use of historical five-year averages to inform future supply and demand balancing outcomes after a large generator exits the market is unlikely to reflect reality. In the years following the Hazelwood closure, some previously mothballed generating units returned to service while others increased output in response to the tightening of supply and demand and the resultant impact on both spot and future prices. The current process for capping extrapolation does not allow for consideration of this type of response.

Key considerations

The process for capping extrapolation of generation is unlikely to be a problem for the 2021-22 financial year, but in subsequent years there is potential for the exit of multiple large generators. This is likely to be somewhat offset by the ongoing increase in intermittent generation capacity, but the ongoing suitability of the current methodology should be considered now, taking into account the Hazelwood example.

Questions

- Do stakeholders see merit in retaining the current capping process, or identify any additional considerations/alternatives that would be valuable in improving the reasonableness of MLF outcomes following the exit of a large generator?

3.4.4. Parallel AC/DC interconnectors

Issue

The current FLLF methodology prescribes that, where an AC interconnector is parallel to a DC interconnector, the DC interconnector flows are designated by the flow on the AC counterpart and the ratio of the capacities. This is reflected in clause 5.5.3 of the current methodology:

> *For* inter-regional *flows where a regulated DC link is in parallel to other AC circuits, AEMO apportions flow between the DC and AC elements in proportion to the maximum capabilities of the DC and AC circuits. AEMO uses different ratios where the capabilities are not the same in each direction.*

For example, for Murraylink this equates to,

$$M = H \times (\frac{MC}{HC})$$

Where

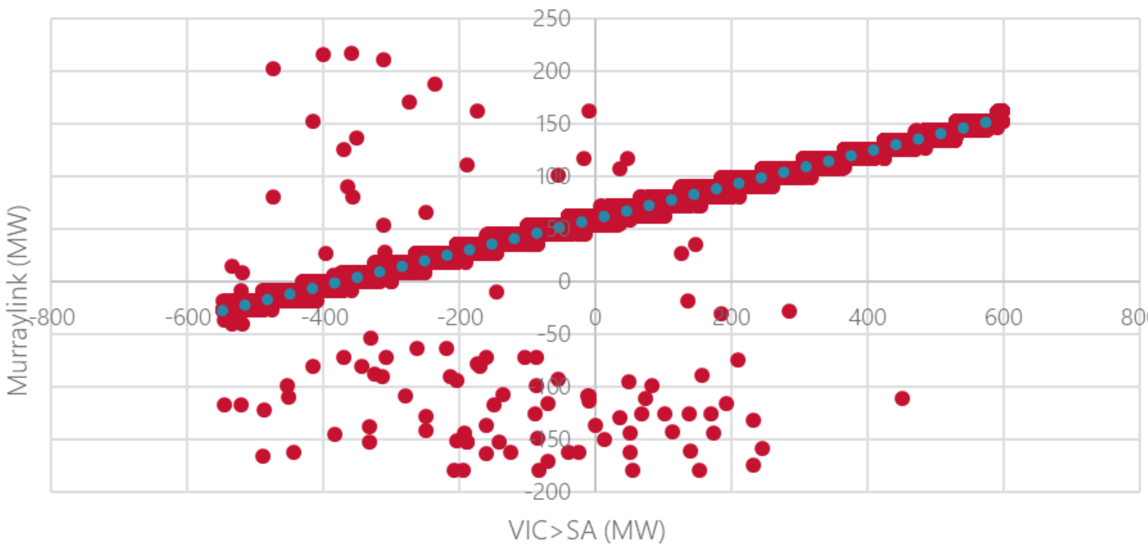
- M = Murraylink Flow (VIC>SA)
- H = Heywood Flow (VIC>SA)
- MC = Murraylink Capacity
- HC = Heywood Capacity

When unconstrained, the flow across parallel interconnectors are scheduled by the NEM Dispatch Engine (NEMDE) in a manner that optimises losses. While the resultant relationship is linear, it is not driven by capacity and there is an offset (Murraylink flow is not zero when Heywood flow is zero).

Key considerations

AEMO has identified and trialled a method for allocating flows on DC interconnectors with AC counterparts based on historical observations rather than rated capacities. This process involves obtaining historical flows for both interconnectors, excluding results impacted by constraints (MLF process is based on system normal conditions) and ascertaining the line of best fit. Figure 3 shows the historical data and the relationship for Heywood and Murraylink flows for the 2019-20 financial year.

Figure 3 Historical VIC > SA vs Murraylink unconstrained flows



Using a combination of the existing capability of the MLF engine and loads (to reflect offset), AEMO has successfully trialled the equation for the line of best fit in the MLF engine. Figure 4 shows the resultant flows. As can be seen, this has resulted in an outcome that is largely reflective of the unconstrained historical results and as such a more accurate reflection of actual outcomes than the use of capacities to determine Murraylink flows.

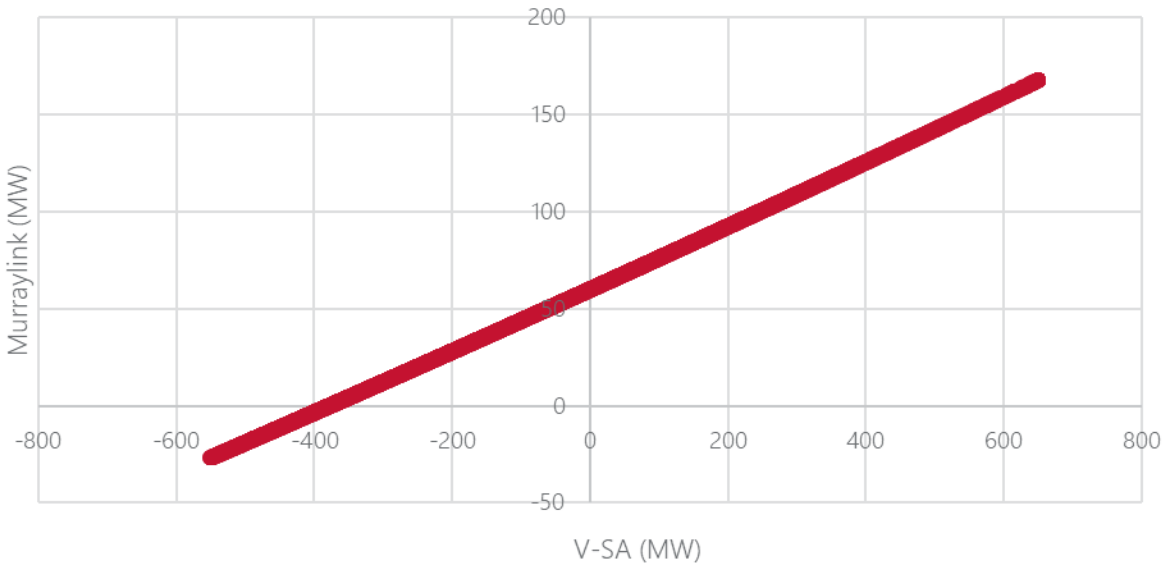
With this process, the relationship between Murraylink and Heywood flows is revised to:

$$M = H \times 0.1606 + 60.185$$

Where

- M = Murraylink Flow (VIC>SA)
- H = Heywood Flow (VIC>SA)

Figure 4 MLF Engine VIC > SA vs Murraylink supply and demand balancing outcome



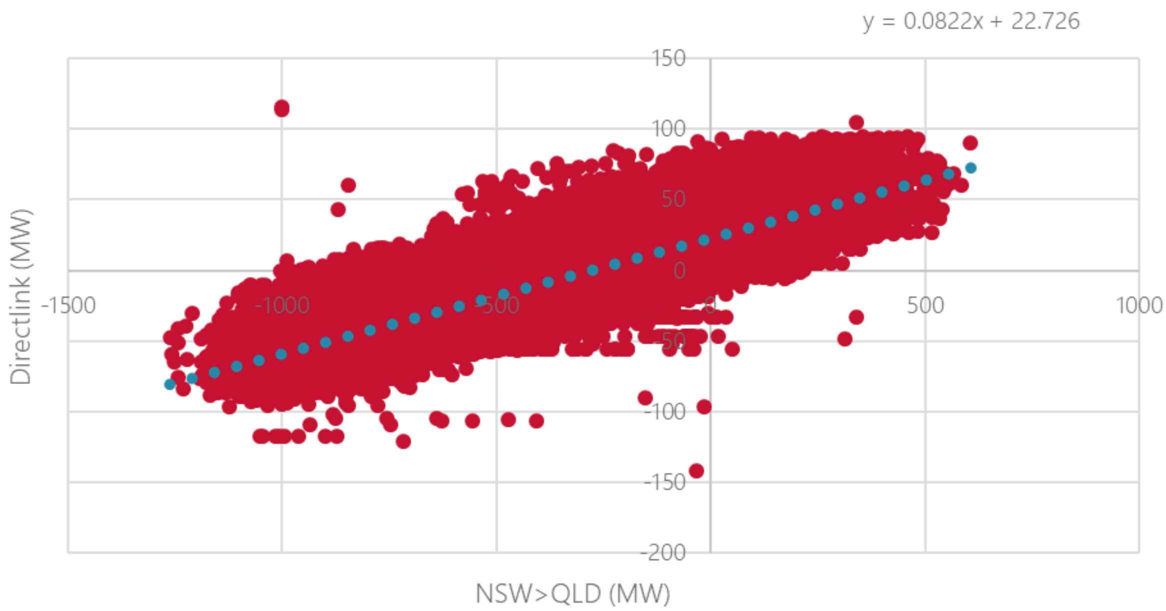
While Directlink is somewhat more complex in nature, as it does not form part of an interconnector (it is downstream of Terranora) and resides wholly in New South Wales, the same principle can apply. Due to the presence of load between the Terranora interconnector and Directlink, the relationship between Directlink and the AC counterpart is not as direct as the relationship between Murraylink and its AC counterpart, as Figure 5 shows.

An additional term may be required for Directlink, to reflect the impact of the load between Directlink and Queensland. This term may be derived by investigating the delta between the expected outcome based on the line of best fit and the historical outcome. This term would function as a correction for the impact of load between Directlink and the New South Wales to Queensland border.

The MLF engine also has the capacity to implement both seasonal (summer, winter) and time of day (peak, off-peak) ratios, in addition to the additional term for Directlink to account for the load at Terranora a dynamic ratio may prove valuable.

Regardless, the derivation and application of a line of best fit based on historical data should result in a more meaningful and accurate outcomes than the traditional process of using a ratio of the rated capacities.

Figure 5 Historical NSW > QLD vs Directlink unconstrained flows



Questions

- Do stakeholders see merit in the approach to operate DC interconnectors that are parallel to AC interconnectors as a ratio that is derived from historical flows within the reference year?
- Can stakeholders identify any additional considerations/alternatives that would lead to an improvement in the supply and demand balancing outcomes of DC interconnectors in parallel with AC interconnectors?

3.4.5. Intra-regional constraints

Issue summary

Increasingly, AEMO has observed high impact intra-regional constraints under system normal conditions (without prior network outages), particularly in areas with large levels of new generation. While some of these constraints are related to thermal limits, most are non-thermal in nature (for example, voltage collapse and system strength).

Historically, high impact intra-regional constraints have not regularly been binding under system normal conditions, so the FLLF methodology and the associated tools and processes were not designed with intra-regional constraint implementation as a consideration. Currently, the methodology contains no reference to the treatment of intra-regional constraints.

Intra-regional constraints may severely restrict the output of impacted generators during high generation and low local load conditions, making it important for these limitations to be appropriately modelled in MLF studies to ensure the resultant MLFs for the impacted generators are appropriate.

It should be noted that the MLF process uses a system normal network model for all intervals, and as such constraints relating to network outages are not considered.

Key considerations

In the most recent MLF studies, AEMO identified material system normal intra-regional constraints for inclusion by liaising with relevant specialist groups within AEMO and seeking advice on limits from transmission network service providers (TNSPs).

The constraints considered are reported alongside the annual MLF results (see Appendix A2.4 in the 2020-21 MLF report), and AEMO relies on the principles in clause 5.9 of the current methodology to account for these constraints in MLF determinations.

In the FLLF methodology, intermittent generators are modelled as energy limited (inflexible), hence they are rarely adjusted by the minimal extrapolation process when balancing supply and demand. As such, when intermittent generators are subject to constraints, the input megawatt (MW) values are adjusted to manage the constraint.

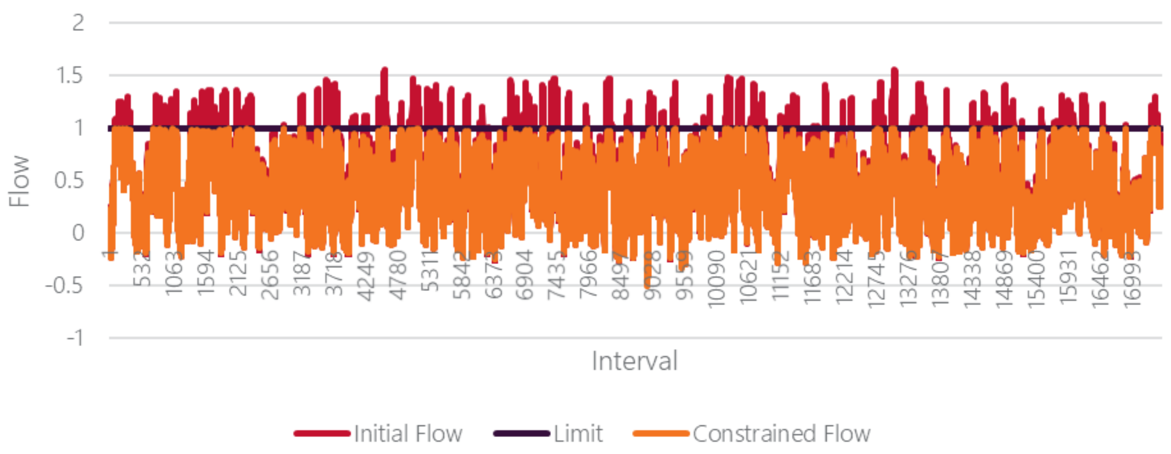
The current intra-regional constraints can currently be divided into two broad categories:

- Limit on net output of a defined set of generators (may also include, for example, individual limits and number of inverters).
  - In this scenario, the output of a set of generating units is limited to a value that may be either static or dynamic. For dynamic limits, the value can be derived from the operation of other generators. An example is the system strength constraint within South Australia, which limits the output of semi-scheduled intermittent generation based on the combination of relevant scheduled generating units online.
  - These constraints are modelled by estimating the limit for each interval and assessing the relevant information (generation and demand) and applying pro-rata reductions to the relevant generating units.
- Constraints implemented as line limits or transfer limit across a cut-set.
  - In this scenario, a set of generators is constrained where flows across a cut-set exceed the identified transfer limit. An example is a thermal constraint, where generator output is limited to manage transfer within the specified limitation.
  - As these constraints require line flows as an input, an unconstrained MLF run is performed to obtain supply and demand balancing outcomes and flows for relevant lines. For each interval, the monitored flows are compared to the transfer limit. Where the limit is exceeded, the pro-rata reductions are applied to the relevant generating units to reduce flows below the transfer limit.
  - When managing transfer limits, generation at physically different locations on the transmission network will have different levels of contribution to the relief of the limit. In reality, reductions are performed on a least-cost basis where consideration is given to a generator's coefficient in the relevant constraint equations, MLF and its offer. However, to align with the minimal extrapolation theory, reductions are performed on a pro-rata basis when implementing constraints of this form for MLF purposes. When adjusting generating unit output to manage flows within meshed sections of the network, a reduction of 1 MW will not equate to a relief of 1 MW. An additional term is therefore implemented to account for the requirement that the reduction in generation must exceed the level of violation.
  - As the MLF process involves adjustment of all relevant generating units, and the reductions are performed on a pro-rata basis, an additional factor is required to ensure the reductions are sufficient to effectively manage the limit. This ratio is currently obtained through an iterative process, where several studies are performed to ascertain an appropriate value.
  - In some scenarios, where a single factor is deemed insufficient, several factors may be implemented. This has historically been based on the time of day where a strong diurnal generation pattern exists, additionally where the observed violations vary significantly in nature the

factor may relate to the volume of the violation. When multiple factors are used, they are each derived from an iterative process where several studies are performed for each factor to ascertain an appropriate value.

– An example (normalised) of the outcomes for a thermal limit constraint implemented in the 2020-21 MLF study can be seen in figure 6. Note that the reductions which occur at times of non-violation are the result of the management of additional constraints which in turn have an impact on the flows depicted below.

Figure 6 Thermal constraint management example



> **Questions**
>
> - Do stakeholders see merit in the addition of a section to cover the process for management of intra-regional constraints?
> - Can stakeholders identify any additional considerations/alternatives to manage identification and control of intra-regional constraints?

3.5. Publication

Publication relates to the reports and studies that are made available by AEMO to inform and support the MLF process and the industry. Three issues have been identified with respect to publication.

3.5.1. Transparency of MLFs

Issue

In recent years, MLFs in certain areas have changed substantially year on year. The changes are primarily being driven by significant increases in generation capacity in remote locations of the transmission network. Additionally, the new generation capacity is driving material changes in forecast flows across interconnectors which is having a material impact on MLFs in areas close to proximity to interconnectors.

Historically, two MLF publications were produced on an annual basis, a draft and final version published within a month of each other. This resulted in stakeholders having poor visibility of MLF movements and outcomes prior to the draft MLF publication.

Key considerations

AEMO has now committed to publishing two additional MLF reports for a financial year, bringing the total number of MLF reports to four. The additional two reports are a sensitivity study and a preliminary MLF report.

The sensitivity study, the first of which is expected to be published in August 2020, will consider the impact of several different scenarios (such as generation, load, COVID-19) and their potential impact on MLFs.

The preliminary MLF report is intended to be a preliminary indication of the MLF movements and outcomes for the target year, to provide stakeholders with additional time to consider and respond to the impact of future MLFs.

For reference, the table below shows the timeline for the proposed publications in 2020-21, for the MLFs to apply in 2021-22.

Table 2 MLF publication timeline for FY21-22

Study/report	Indicative date for FY21-22
Scenario sensitivity study	August 2020
Energy generation forecast study (indicative extrapolation)	October 2020
Preliminary report	November 2020
Draft report	March 2021
Final report	April 2021

Questions

- Did stakeholders find value in the publication of preliminary MLFs for the 2020-21 financial year (published in November 2020)?
- Do stakeholders consider the proposed timing for reporting is appropriate?

3.5.2. Intra-year revisions

Issue

Under clause 3.6.2(i)(2) of the NER, AEMO must revise MLFs intra-year where a connection point is modified and in AEMO's reasonable opinion the modification amounts to a material change in capacity.

Intra-year revisions of MLFs are relatively infrequent in nature, however stakeholders have expressed concern about unexpected changes. The current FLLF methodology does not address the process for revising MLFs intra-year.

Key considerations

AEMO proposes to increase the transparency of intra-year revisions of MLFs by:

- Specifying fixed periods for revisions to the MLF publication for the relevant year which will reflect any intra-year revisions that have occurred in that period, likely quarterly.
- Specifying a process for notification of intra-year MLF revisions.

- Publishing[7] additional MLF values that will be updated daily from production settlement systems.

Questions

- Do stakeholders consider the proposed improvements to intra-year revisions of MLFs warranted?
- Can stakeholders identify any additional considerations/alternatives that would further improve transparency regarding intra-year revisions of MLFs?

3.5.3. Energy generation forecast study (previously indicative extrapolation study)

Issue summary

Each October, AEMO publishes indicative extrapolation results in the Energy Generation Forecast Study (previously called the Indicative Extrapolation Study)[8]. This publication informs stakeholders of the forecast generation levels for the target year in gigawatt-hours (GWh), and seeks to prompt stakeholders to provide feedback to AEMO if they believe there is a material and verifiable reason the values published are not an appropriate representation of their expected generation output in the target year.

Currently, the process only includes thermal and hydro generation. No results are published for wind or solar generation, hence they have no opportunity to confirm and provide feedback on their forecast output levels.

Key considerations

AEMO proposes to expand the current publication to include forecast generation levels for both wind and solar, allowing proponents to provide feedback where they ascertain the forecast values are not an appropriate representation of their expected generation output in the target year.

Questions

- Do stakeholders see merit in including wind and solar in the Energy Generation Forecast Study?
- What steps could be taken to improve stakeholder engagement in relation to the Energy Generation Forecast Study publication?

3.6. Unexpected and unusual system conditions

Unexpected and unusual system conditions may arise in circumstances when the FLLF methodology does not provide adequate guidance. In such cases AEMO is expected to exercise its judgement on potential adjustments based on the principles in the NER and the methodology. One issue has been identified with respect to unexpected and unusual system conditions.

[7] These publications will be made available at http://www.nemweb.com.au/Reports/Current/Marginal_Loss_Factors/
[8] Historical versions can be found at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/market-operations/loss-factors-and-regional-boundaries

3.6.1. Treatment of problematic historical data

Issue summary

In 2020, multiple significant events have impacted NEM outcomes:

- Bushfires led to abnormal network configurations, and reduced load in impacted regions.
- Severe weather events led to a sustained material network outage (separation of South Australia and part of south-west Victoria).
- COVID-19 has led to shifts in load patterns, with load transfer from CBD locations to suburban areas as well as a change in the diurnal profile of load (later morning peak, earlier evening peak). To date, the impact to net load has been reasonably mild, with a net reduction of an estimated 2.1% partly offset by an increase in heating load of 1.4% as a result of cooler weather. A material decrease in commercial demand (10-20%) has largely been offset by an increase in residential load. Despite the minimal change in operational demand, there will be a shift between connection points as demand transfers from commercial loads to residential loads[9].

For the 2021-22 MLFs, the reference year will reflect the combined impact of all these events on load and generation.

Key considerations

When unexpected or unusual system conditions arise, either within the historical data or within the target year, AEMO may use clause 5.9 to form a judgement on whether and how to adjust for issues that are not considered within the remainder of the methodology. In such cases AEMO is to base any judgement on the principles of both the NER and section 5 of the methodology.

Clause 5.9 was included to accommodate exceptional circumstances and AEMO considers that it was intended to be used rarely. Accordingly, where similar recurring circumstances arise or are foreseen, it may be appropriate to consider providing a specific process within the methodology to account for that impact.

In relation to load, the issue of problematic historical data shares challenges with the definition of the reference year (see Section 3.1.1). The systems which are tied to several different workstreams within AEMO currently all function on a financial year basis. As such, substituting problematic historical data with data from a non-reference year is challenging.

From a load forecasting perspective, corrections can be made to historical data through the implementation of a synthetic profile which allows the profiles to be adjusted to minimise the impact of problems associated with temporary load transfer (lockdowns and shift from CBD to suburban areas) and load reductions (reduced load at regional holiday destinations materially impacted by bushfires).

In relation to generation outcomes, supply and demand balancing outcomes for the target year will be modelled with a system normal network configuration. While this will result in appropriate movements in supply and demand balancing, it will not correct for underlying issues relating to the historical network configuration and the associated impact of the relevant constraints, interventions and directions.

AEMO will investigate the materiality of the impact of the network configurations resultant from 2019-20 bushfires and severe weather events and the impact of COVID-19 on load. Where materially problematic historical data is identified, AEMO will seek to identify processes for resolution and will provide further information on these in the annual report.

[9] For more information on the impact of COVID-19, refer to AEMO's Quarterly Energy Dynamics Q2 2020 at https://aemo.com.au/energy-systems/major-publications/quarterly-energy-dynamics-qed

Questions

- Do stakeholders believe the use of clause 5.9 is appropriate for management of problematic historical data resulting from events such as the 2020 fires and COVID-19, and if not, can they identify any further considerations/alternatives?

4. OTHER MATTERS

Other matters have been identified as relevant to the methodology, but are unlikely to be implemented through this consultation, due to limitations in the current NER framework or the need for more detailed analysis. These issues have been grouped based on the aspect of the methodology to which they relate:

- Network data.
- Intra-regional static loss factors.
- Inter-regional loss factor equations.

AEMO welcomes feedback on these matters, and in particular if there are any alternative options that should be considered.

4.1. Network data

4.1.1. Transmission treatment

Issue summary

Since the introduction of Dedicated Connection Assets (DCAs), concerns relating to MLFs have been raised in scenarios where multiple generators are located within a single DCA, and in particular where these generators are not owned by a single proponent. For large DCAs, additional proponents (beyond the original proponent) may request access to the DCA, under an access policy approved by the Australian Energy Regulator (AER).

Under the current NER, only a single MLF may be applied to a DCA. Where generation of different technologies owned by different proponents is connected to the DCA, this is likely to result in a material level of cross-subsidisation in relation to the MLF and inequitable financial outcomes.

Key considerations

This issue is included in a rule change proposal[10] submitted by AEMO and currently under consideration by the AEMC. The proposal aims to resolve several issues relating to the current DCA framework, including an improvement to the treatment and allocation of MLFs within DCAs.

4.2. Intra-regional static loss factors

4.2.1. MLFs in close proximity to borders and interconnectors

Issue summary

Where loads and/or generators are located within remote locations and within close proximity to an interconnector, large year-on-year variations in MLF outcomes are possible as a result of changes in interconnector flows.

Where a load or generator is located in close proximity to an interconnector that:

- Has increased exports (including decreased imports), there will be an increase in flows from the RRN and upward pressure on MLFs.
- Has increased imports (including decreased exports), there will be an increase in flows to the RRN and downward pressure on MLFs.

[10] The rule change can be found at https://www.aemc.gov.au/rule-changes/connection-dedicated-connection-assets

MLF theory aligns with the underlying 'hub and spoke' concept of the NEM market design. While regions are connected in the hub and spoke model, from an MLF perspective they are decoupled with inter-regional loss factors accounting for transfer between regions. Both loads and generators within a region are referenced to the relevant RRN when calculating MLFs, therefore MLFs in close physical proximity can have materially different outcomes where they are located in different regions and hence referenced to different RRNs.

Key considerations

AEMO does not consider the issue of the volatility of MLFs of loads and generators in close proximity to interconnectors can be practically addressed within the current methodology.

4.2.2. AC load flow

Issue summary

The current MLF calculation engines use AC power flow to ascertain the base case for each half-hour of the financial year, then uses an AC sensitivity matrix (also known as a Newton-Raphson Jacobian matrix) to calculate the MLFs for each half-hour.

While use of an AC load flow in itself is not problematic, there are alternative options which are used in other markets around the world and by local stakeholders to perform MLF studies.

Key considerations

One alternative used for loss calculations in other jurisdictions and locally by stakeholders seeking to study MLFs is the decoupled (not to be confused with direct current or DC) load flow method. This retains use of an AC load flow, however it negates the requirement to consider reactive flows.

Decoupled load flows provide less reflective MLFs (ignore reactive power flows), however the process is significantly simpler and does not require a complex load flow engine. This would in turn reduce the complexity of MLF calculations and improve the ability of stakeholders to replicate AEMO's MLF outcomes and perform studies of their own.

4.3. Inter-regional loss factor equations

4.3.1. Looped regions

Issue summary

Currently all inter-regional connections within the NEM are radial in nature, however this may change in future. For example, it is possible that Victoria, South Australia and New South Wales will be interconnected as a result of the proposed EnergyConnect interconnector between South Australia and New South Wales. This is expected to be challenging from an inter-regional loss point of view.

Key considerations

AEMO currently has a project to identify the potential impacts of EnergyConnect and the associated issues that will arise as a result of looped regions.

5. SUMMARY OF MATTERS FOR CONSULTATION

AEMO seeks comments and feedback on any of the matters raised in this paper, or any other matters that may be relevant to the methodology. To assist stakeholders, the table below summarises the questions identified for each issue.

Table 3 Issues and associated questions

Issue	Related questions
Load forecast data	
Reference data	• Is there a perceived sustained material benefit in revising the definition of reference year to incorporate more recent data?
Controllable network element flow data	
MNSP rule change implementation	• Is there a material benefit in incorporating Basslink into the supply and demand balancing process, and if so, should the historical flows from the reference year be used as an initial level of operation? • Can stakeholders identify any additional considerations/alternatives for the inclusion of Basslink into the supply and demand balancing process?
Generator data	
Generator capacities	• Do stakeholders see merit in the use of typical summer capacities as an input to the MLF process?
New generation profiles	• Do stakeholders see merit in the approach of AEMO producing generation profiles internally and the inclusion of commissioning activities within the profiles? • Can stakeholders identify any additional considerations/alternatives?
Supply demand balance	
Minimum stable operation levels of thermal plant	• Can stakeholders identify any additional sources for identifying the stable minimum generation levels, and do stakeholders have any considerations/alternative suggestion as to how stable minimum generation levels may be managed?
Minimal extrapolation theory	• Do stakeholders see merit in retaining the existing minimal extrapolation theory and if so, should it be expanded? • What alternatives to minimal extrapolation theory do stakeholders consider suitable?
Extrapolation capping	• Do stakeholders see merit in retaining the current capping process, or identify any additional considerations/alternatives that would be valuable in improving the reasonableness of MLF outcomes following the exit of a large generator?
Parallel AC/DC interconnectors	• Do stakeholders see merit in the approach to operate DC interconnectors that are parallel to AC interconnectors as a ratio that is derived from historical flows within the reference year? • Can stakeholders identify any additional considerations/alternatives that would lead to an improvement in the supply and demand balancing outcomes of DC interconnectors in parallel with AC interconnectors?
Intra-regional constraints	• Do stakeholders see merit in the addition of a section to cover the process for management of intra-regional constraints? • Can stakeholders identify any additional considerations/alternatives to manage identification and control of intra-regional constraints?
Publication	
Transparency of MLFs	• Did stakeholders find value in the publication of preliminary MLFs for the 2020-21 financial year (published in November 2020)? • Do stakeholders consider the proposed timing for reporting is appropriate?

Issue	Related questions
Intra-year revisions	• Do stakeholders consider the proposed improvements to intra-year revisions of MLFs warranted? • Can stakeholders identify any additional considerations/alternatives that would further improve transparency regarding intra-year revisions of MLFs?
Energy generation forecast study	• Do stakeholders see merit in including wind and solar in the Energy Generation Forecast Study? • What steps could be taken to improve stakeholder engagement in relation to the Energy Generation Forecast Study publication?
Unexpected and unusual system conditions	
Treatment of problematic historical data	• Do stakeholders believe the use of clause 5.9 is appropriate for management of problematic historical data resulting from events such as the 2020 fires and COVID-19, and if not, can they identify any further considerations/alternatives?

Submissions on these and any other matter relating to the proposal discussed in this Issues Paper must be made in accordance with the Notice of First Stage of Consultation published with this paper **by 5.00 pm (Melbourne time) on 25 September 2020**.

APPENDIX A. GLOSSARY

Term or acronym	Meaning
AC	Alternating Current
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
BOM	Bureau of Meteorology
DC	Direct Current
DCA	Dedicated Connection Asset
ESOO	Electricity Statement of Opportunities
FLLF	Forward-Looking Transmission Loss Factor
FY	Financial Year
GWh	Gigawatt-hour
ISP	Integrated System Plan
MLF	Marginal Loss Factor
MNSP	Market Network Service Provider
MW	Megawatt
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine
NEMWeb	NEM Data Portal
NER	National Electricity Rules
NREL	National Renewable Energy Laboratory
RRN	Regional Reference Node
SAM	System Advisory Model
SRMC	Short Run Marginal Cost
TNSP	Transmission Network Service Provider