Forward-Looking Transmission Loss Factor Methodology Review

Working Group – Session 2

24 May 2024

We acknowledge the Traditional Owners of country throughout Australia and recognise their continuing connection to land, waters and culture.

We pay respect to Elders past and present.

Agenda

1. Introduction
2. Background
3. Objectives
4. Known industry concerns
5. TPRICE replacement
6. Notable issues
7. Q&A

Competition and meeting protocol

AEMO

- AEMO is committed to complying with all applicable laws, including the Competition and Consumer Act 2010 (CCA).
- In any dealings with AEMO regarding the procurement of goods or services (including for Interim ReliabilityReserves), all participants agree to comply with the CCA (including the competition law obligations set out below) and this Protocol. Participants must arrange for their representatives to be briefed on competition law risks and obligations.
- Competition law obligations
- The CCA prohibits anti-competitive conduct, including:
- 1. Cartel conduct – arrangements between competitors to: – fix prices – restrict supply or acquisition of goods or services – allocate customers or territories – rig bids. A cartel can be entered into even though competitors never meet or speak directly. This is known as a 'hub and spoke cartel' where a third party facilitates the cartel by passing on information and commitments between competitors. The third party can be liable for this conduct.
- 2. Concerted practices – other cooperation between competitors with the purpose, effect or likely effect of substantially lessening competition (eg sharing competitively sensitive information with competitors).
- 3. Any other contract, arrangement or understanding which has the purpose, effect or likely effect of substantiallylessening competition.
- 4. Any conduct by a company with market power which has the purpose, effect or likely effect of substantiallylessening competition.
- A contravention of the CCA can result in significant penalties, including criminal sanctions for cartel conduct (including jail terms for individuals).

Competition and meeting protocol

Participants in AEMO discussions must:

- ensure that discussions are limited to the matters contemplated by the agenda for the discussion
- make independent and unilateral decisions about their commercial positions and approach in relation to the matters under discussion with AEMO
- immediately and clearly raise an objection with AEMO or the Chair of the meeting if a matter is discussed that the participant is concerned may give rise to competition law risks or a breach of this Protocol.

Participants in AEMO meetings must not discuss or agree on the following topics:

- which customers they will supply or market to
- the price at which Participants will supply
- bids or tenders, including the nature of a bid that a Participant intends to make or whether the Participant will participate in the bid
- which suppliers Participants will acquire from (or the price or other terms on which they acquire goods or services).

Under no circumstances must Participants share Competitively Sensitive Information.

- Competitively Sensitive Information means confidential information relating to a Participant which if disclosed to a competitor could affect its current or future commercial strategies, such as pricing information, customer terms and conditions, supply terms and conditions, sales, marketing or procurement strategies, product development, margins, costs, capacity or production planning.

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Background

Johnny Mangala

Background

The Forward-Looking Transmission Loss Factor (FLLF) Methodology (methodology) is a prescribed document under the National Electricity Rules (NER) owned by AEMO.

MLFs provide the following benefits to the market.

Efficient dispatch outcomes

- Minimisation of losses.

Locational investment signalling

- For both load and generation.

Technological investment signalling

- MLFs are sensitive to technology where underlying energy resource has strong diurnal pattern.
- Where an area is saturated with one technology options may exist for other technologies, in particular storage.

Positive intra-regional residues

- Market operates with net positive residues and remains **solvent**, rather than negative and at risk of becoming **insolvent**.

FLLF Methodology Principals - NER 3.6.2(e)

To the right is an extract from the NER detailing the requirements for the FLLF methodology.

All resultant changes to the methodology must be considerate of the limitations imposed by 3.6.2.(e).

To change these constraints, a rule change submission is required followed by a determination by the AEMC actioning change.

(e) In preparing the methodology referred to in clause 3.6.2(d), *AEMO* must implement the following principles:

(1) *Intra-regional loss factors* are to apply for a *financial year*.

(2) An *intra-regional loss factor* must, as closely as is reasonably practicable, describe the average of the *marginal electrical energy losses* for electricity transmitted between a *transmission network connection point* and the *regional reference node* in the same *region* for each *trading interval* of the *financial year* in which the *intra-regional loss factor* applies.

(2A) *Intra-regional loss factors* must aim to minimise the impact on the *central dispatch* process of *generation* and *scheduled load* compared to that which would result from a fully optimised dispatch process taking into account the effect of losses.

(3) Forecast *load* and *generation* data for the *financial year* for which the *intra-regional loss factor* is to apply must be used. The forecast *load* and *generation* data used must be that *load* and *generation* data prepared by *AEMO* pursuant to clause 3.6.2A.

(4) The *load* and *generation* data referred to in clause 3.6.2(e)(3) must be used to determine *marginal loss factors* for each *transmission network connection point* for the *financial year* to which the *load* and *generation* data relates.

(5) An *intra-regional loss factor* for a *transmission network connection point* is determined using a volume weighted average of the *marginal loss factors* for the *transmission network connection point*.

Consultation Scope

In scope - Changes to FLLF Methodology

- Supply demand calculation.
- Intraregional limits
- Consideration of storage.

Out of scope – Rules changes

- MLF Principles
- Application period of MLFs.
- Average vs. Marginal.
- Changes to residue management.

Potential for rule change

- Separate working group to be established to examine changes to NER
- Rules change process can take several years from initiation to implementation

Please forward any suggestions to MLF_Feedback@aemo.com.au

Primary Objectives

TPRICE replacement - NEMLF

- Realise benefits of replacement engine.
- Supply and demand balancing configuration.
- Constraint handling.

Applicable for the 2025-26 determination

- Changes as far as practicable, should be actionable for the 2025-26 MLF determinations.

Improved transparency

- Increased coverage of processes.
- Increased/revised reporting requirements.

FLLF methodology review – consultation process

Once the AEMO project team has finalised the issues paper based on stakeholder feedback (in workshops), the formal rules-based consultation for the Forward-Looking Transmission Loss Factors (MLF) methodology review will commence.

1

Pre-consultation workshops to provide an overview of the new supply and demand balancing engine and discuss improvements to the FLLF methodology.

May 2024

2

Issues paper published (based on feedback from workshops).

June 2024

3

Commence formal consultation on FLLF methodology review.

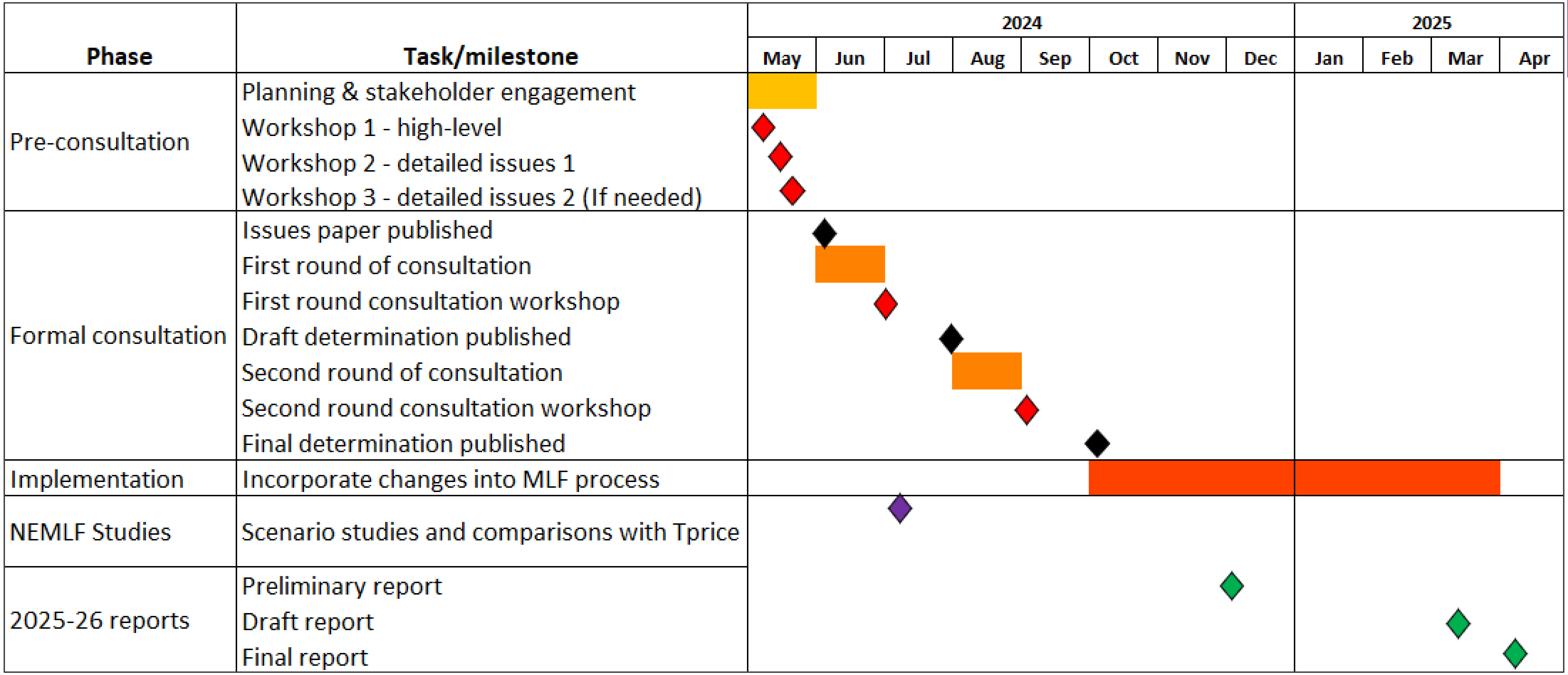
July 2024

4

Final determination published.

October 2024

Schedule


Phase
Task/milestone
2024
2025
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Pre-consultation
Planning & stakeholder engagement
Workshop 1 - high-level
Workshop 2 - detailed issues 1
Workshop 3 - detailed issues 2 (If needed)
Formal consultation
Issues paper published
First round of consultation
First round consultation workshop
Draft determination published
Second round of consultation
Second round consultation workshop
Final determination published
Implementation
Incorporate changes into MLF process
NEMLF Studies
Scenario studies and comparisons with Tprice
2025-26 reports
Preliminary report
Draft report
Final report

Industry concerns - Transparency

A core discussion point during the 2020 FLLF methodology review was increased transparency, the below are some of the actions that eventuated from that.

Preliminary publication

- Have stakeholders seen value in the addition of this report?
- Current feedback has been positive, however limited.

NEMWEB Report

- A live public NEMWEB report is available with live.

Other reports

- Integrated system plan scorecard system.

Industry concerns - Year on Year Volatility

MLFs volatility has been notably high over the last several years in both increases and decreases. The below covers locations that have in recent times been exposed to large year on year variations in MLF outcomes and the associated drivers. Options to address this within the methodology are currently limited.

South-West NSW, north-west Victoria

- Capacity increases
- Congestion

Central and northern Queensland

- Callide C

Areas in close proximity to interconnectors

- Year-on-year variations in flow

Industry concerns – Ability to forecast

Options for forecasting MLF outcomes into the future are currently limited.

AEMO preliminary study

- Early indication of future MLFs and movements, but only year ahead.

AEMO ISP

- A-F grades based on relationship between change in capacity to change in MLF.

AEMO indicative studies

- Allows for inclusion of scenarios (impact of capacity beyond specific project), however based on most recent MLF determination thus year ahead.

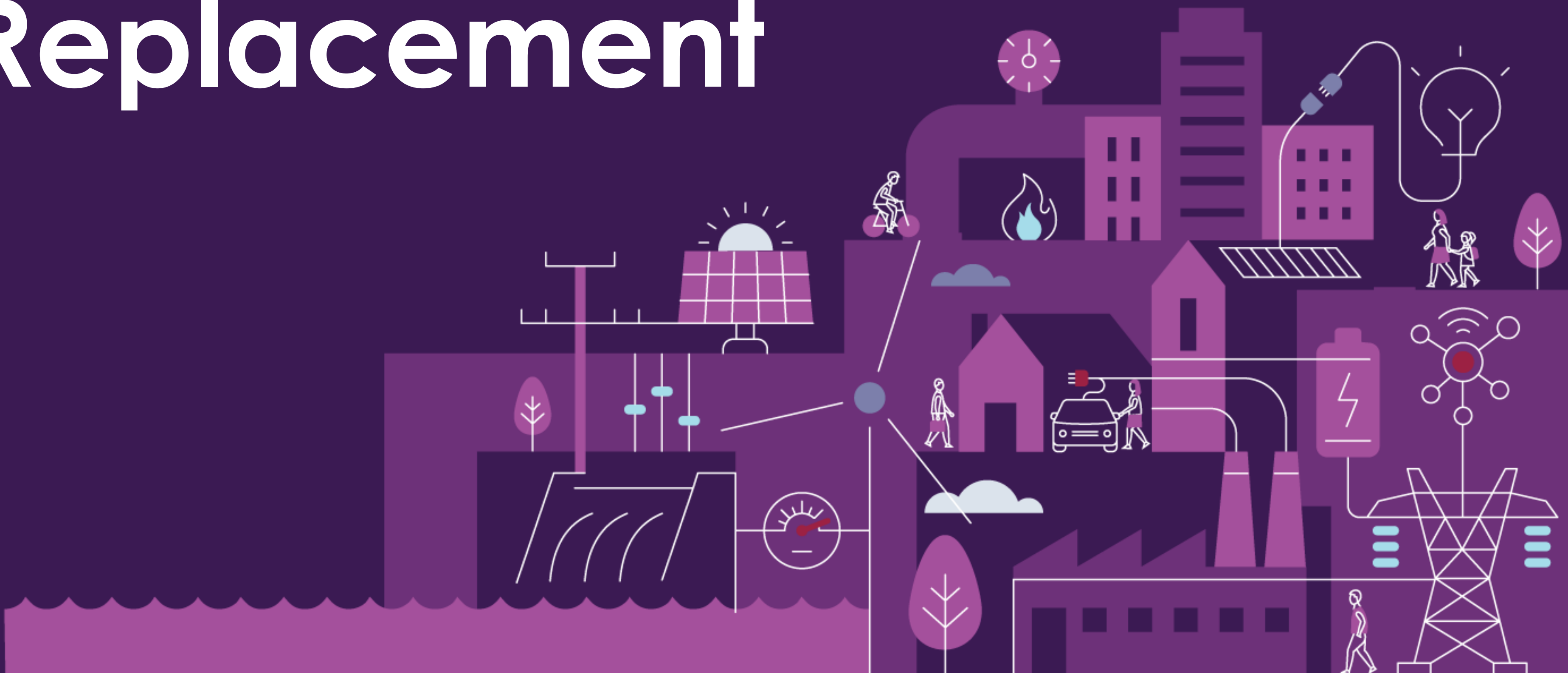
Consultant/inhouse MLF studies

- Allows for more bespoke studies, requires detailed understanding of opaque elements of the MLF process/engine.

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

TPRICE Replacement

Daniel Flynn



TPRICE Replacement (NEMLF)

TPRICE is being replaced by two separate components.

Supply and demand balancing

- Handling of delta between forecast demand and generation.
- Handling of intra and inter regional limits.
- External review has confirmed compliant with the existing FLLF methodology.

AC loadflow (2024)

- Derive MLFs from AC loadflow results based on supply and demand balancing outcomes.

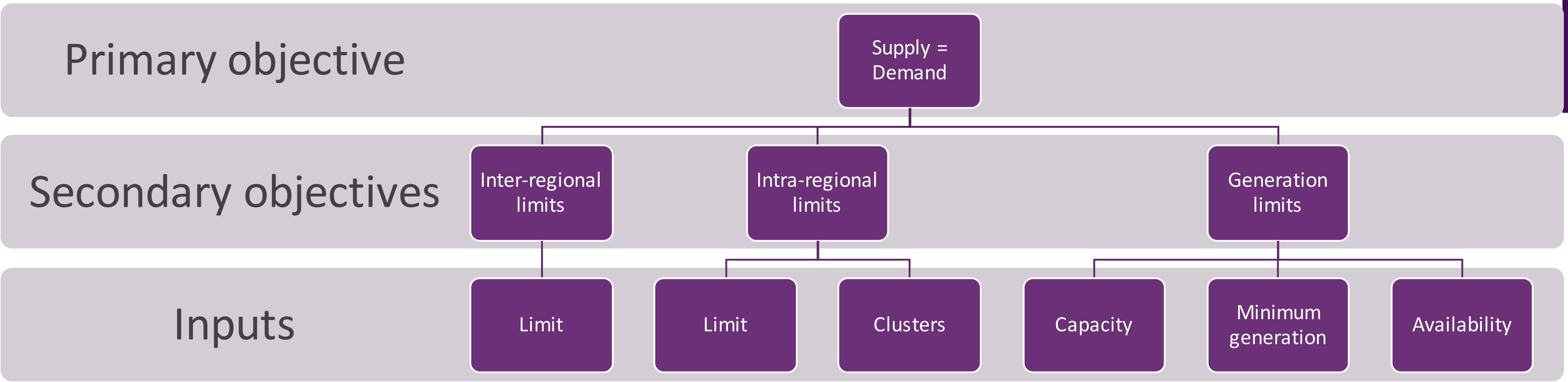
TPRICE Replacement (NEMLF)

AEMO will endeavour to share results comparing TPRICE and NEMLF outcomes in future workshops and the formal consultation process that follows.

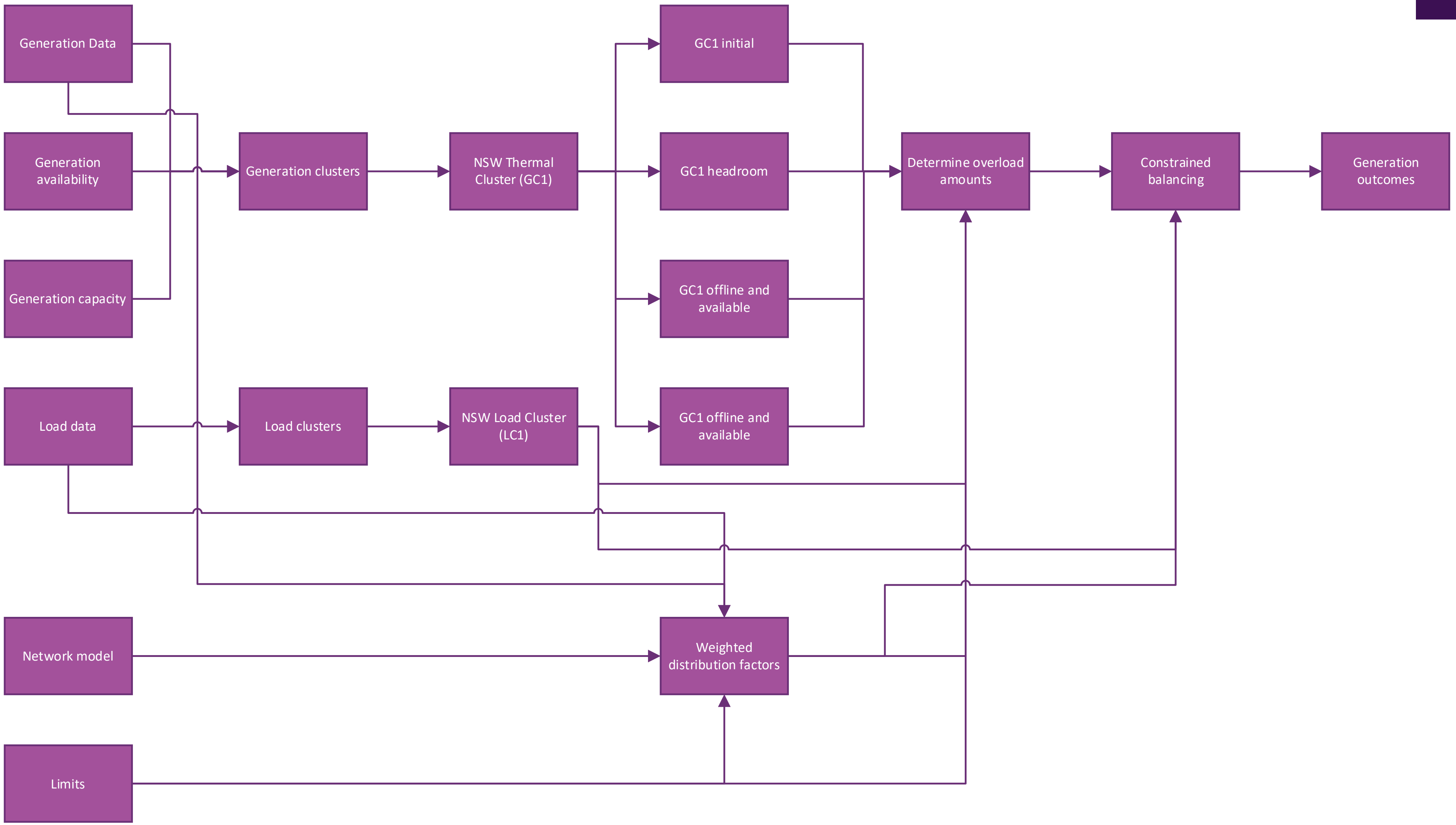
While specific results are not be presented here (intent is to work on studies over the coming weeks and present results) the key observations are:

- The engine has a higher level of accuracy when managing constraints, this has resulted in reduced curtailment and in turn lower loss factors in areas with high levels of congestion.
- In early studies, it was observed that in some scenarios the engine would curtail large volumes of generation from distant assets with low distribution factors.
  - Alterations to the engine have resulted from this and will be discussed later in this workshop.
  - While the outcomes may seem irrational (noting that where fully co-optimised, similar can occur), they were found to be the technically optimal answer following investigation.

TPRICE Replacement (NEMLF)



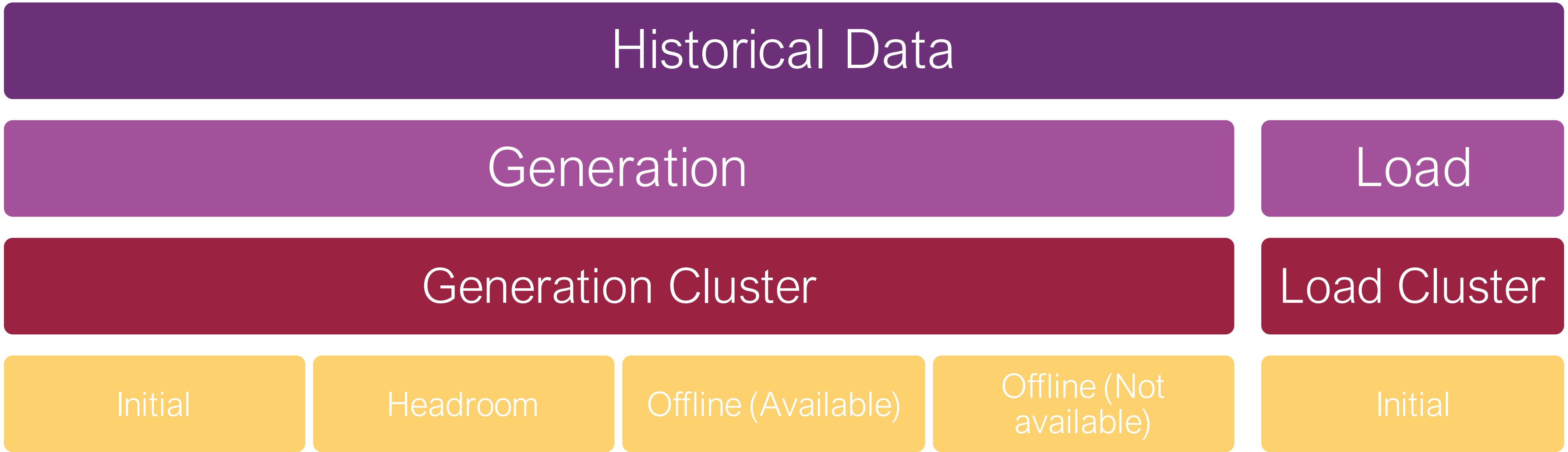
TPRICE Replacement (NEMLF)



TPRICE Replacement (NEMLF) – What is a cluster?

NEMLF uses a concept of clusters to aggregate data, for example all loads within a region can be represented as a single value.

The same is true for generation where the categorisation is the same (for example, thermal and energy constrained), although within that cluster several variants will exist.



TPRICE Replacement (NEMLF) – What is a cluster?

Another feature of clusters, is that it allows for aggregation* or disaggregation of assets when implementing limits.

For intra-regional limits, typically a small subset of generation within a region (and potentially other regions) will be applicable so it is not suitable to rely on the regional based clusters.

High resolution

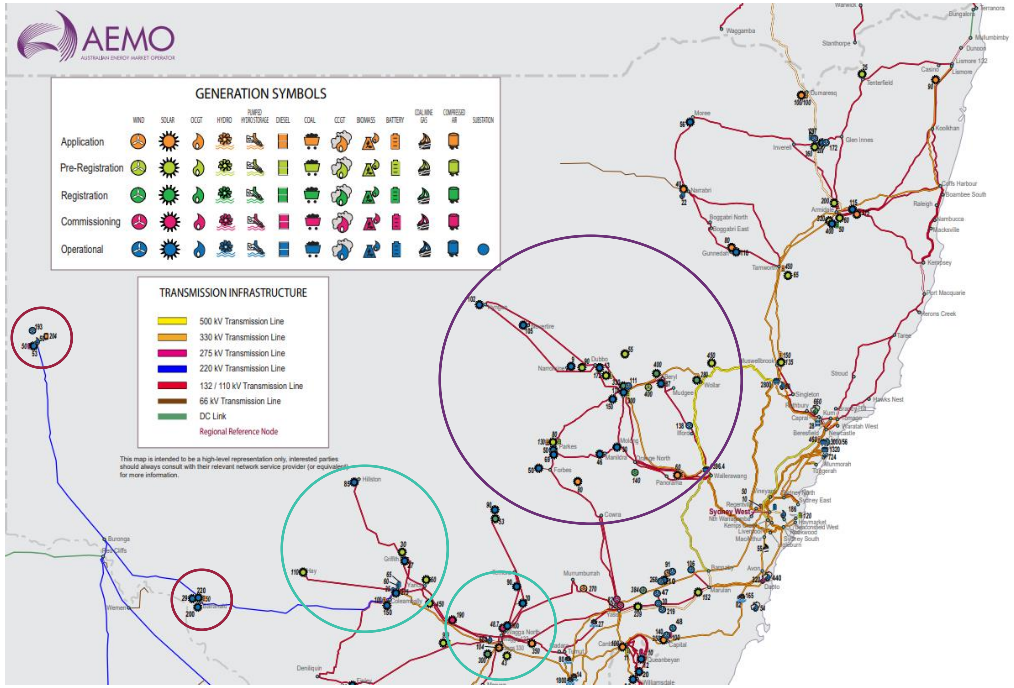
- Low to no socialisation of constraint impacts.
- Highest distribution factor takes all (where technology is equal).

Medium resolution

- Increased socialisation of constraint impacts.
- Impact of congestion socialised within cluster.
  - Higher distribution factor generators curtailed less.
  - Lower distribution factor generators curtailed more.

Low resolution

- High level of socialisation of constraint impacts.
- Impact of congestion heavily socialised within cluster.
  - Higher distribution factor generators curtailed less.
  - Lower distribution factor generators curtailed more.



*Note cluster aggregation is limited by the applied intraregional limits, cannot overlap line with transfer limit

Methodology Review

Daniel Flynn

Methodology Overview – Initial key focus areas

To the right is a list of sections within the methodology that cover the process of determining MLF outcomes.

Sections highlighted have been noted as key items for discussion, however this does not preclude discussion on other topics where stakeholders feel it is warranted.

- 5.1 – Network data
- 5.2 – Load forecast data
- 5.3 – Controllable network element flow data
- 5.4 – Generation data
- 5.5 – Supply-demand balance
- 5.6 – Intra-regional static loss factors
- 5.7 – Inter-regional loss factor equations
- 5.8 – Boundary-point static loss factors (proposed addition)
- 5.~~8~~9 – Publication
- 5.~~9~~10 – Unexpected and unusual system conditions
- 5.~~10~~11 – New connection points or interconnectors
- 5.~~11~~12 – Intra-year revisions

5.3 Controllable network element flow data

Section 5.3 of the methodology covers:

- Regulated network elements (Murraylink and Directlink) in parallel with an AC counterpart.
- Market network service providers (MNSPs).

If Basslink ceases operation as a MNSP, the current methodology has no coverage of how it should be considered in the MLF process.

Options

1. Leave as static (retain use of historical flows).
2. Introduce as controllable element in supply and demand balancing process.

5.4 Generation data

The classification system used in the Generation Information publication often includes projects that are near completion yet still have the ‘anticipated’ classification.

- Additional classification added to Generation Information – Committed*
  - This classification has a reduced set of criteria compared to committed.
- Anticipated now incorporated into other processes (ESOO, MTPASA) with assumptions around timing.

Options

1. Leave as is, committed and committed* included.
2. Expand inclusion with assumptions around timing.

5.5 Supply-demand balance

The replacement of this component of TPRICE uses linear programming to perform supply and demand balancing:

- Implementation partially derived from NEMDE solution.
- Highly customisable.
- Automation of constraints.

This will allow for expansion and/or reconfiguration of the current minimal extrapolation levels (handling of excess generation and insufficient generation).

5.5 Supply-demand balance – Current configuration

Category	Step	Action
Excess supply	-1	• Reduction of **resource constrained** generation on a pro-rata basis
	0	• Reduction of **non-resource constrained** generation on a pro-rata basis
Insufficient supply	1	• Increase of spare capacity of online **non-resource constrained** assets on a pro-rata basis
	2	• Increase of spare capacity of available offline **non-resource constrained** assets on a pro-rata basis
	3	• Dispatchable **pump storage schemes** are reduced
	4	• Increase of spare capacity of unavailable offline **non-resource constrained** assets on a pro-rata basis
	5	• Increase of spare capacity of **hydro** assets on a pro-rata basis
Load shedding	6	• Introduce dummy generation at RRN (reflecting load shedding)

5.5 Supply-demand balance – Current configuration

The following issues have been identified:

- The use of resource limited is overused and not the predominate limit on dispatch order.
- There is no coverage of new technologies (wind, solar, storage, etc).

Options

- Increase the number of available groupings.
    - Retain consideration of resource, for example river run hydro treated as less flexible than dam supplied hydro (use or lose vs storage).
- Move to a true short run marginal cost (SRMC) configuration.
    - Increasingly, capacity is offered at values not equal to the SRMC of the generators.

5.5 Supply-demand balance – Current configuration (storage)

One challenge relates to the incorporation of storage into the supply and demand balancing process, without intertemporal links between intervals, it is challenging to respect SoC limitations.

Options (cost/benefit needs to be considered)

- Utilise historical behaviour as best representation of future behaviour.
  - This should be considered a temporary option; it is likely to become increasingly unreasonable as time progresses.
- Introduce daily scheduling (look at supply demand imbalance and determine outcome outside general supply and demand balancing process).
  - This may introduce material complexity, consideration of value in accuracy if any to be considered.
- Introduce dynamic consideration in supply and demand balancing (place in order adjusts based on perceived SoC).
  - This will likely result in suboptimal behaviour unless limits ensuring sanity are implemented.

Supply and demand balancing challenges

The use of linear programming results in an optimal answer.

Optimal =! Reasonable

Care must be taken when implementing linear programming as while outcome is technically optimal, it may not be reasonable.

Limits - Example

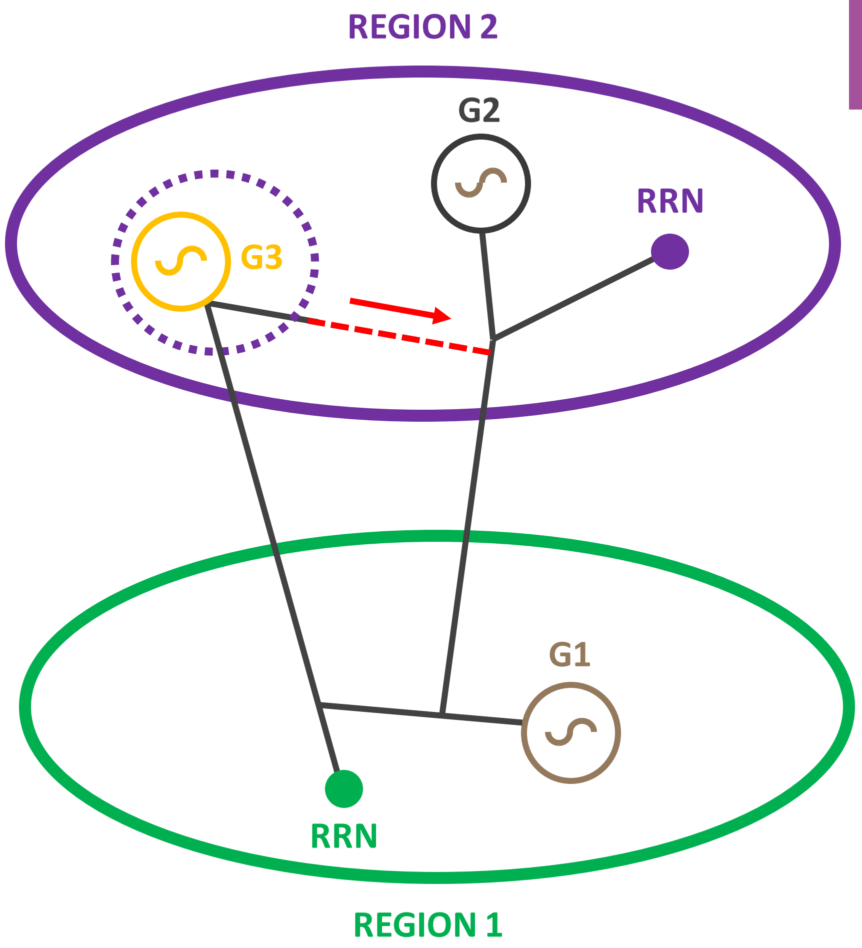
In the example to the right, we have two regions (and RRNs), two coal generators (G1 and G2) and one solar farm (G3).

The dashed red line indicates a line where an intra-regional limit needs to be managed.

In this scenario, the distribution factors (contribution of generation output to flow) may look something like the below:

- G1 = 0.05
- G2 = -0.20
- G3 = 0.90

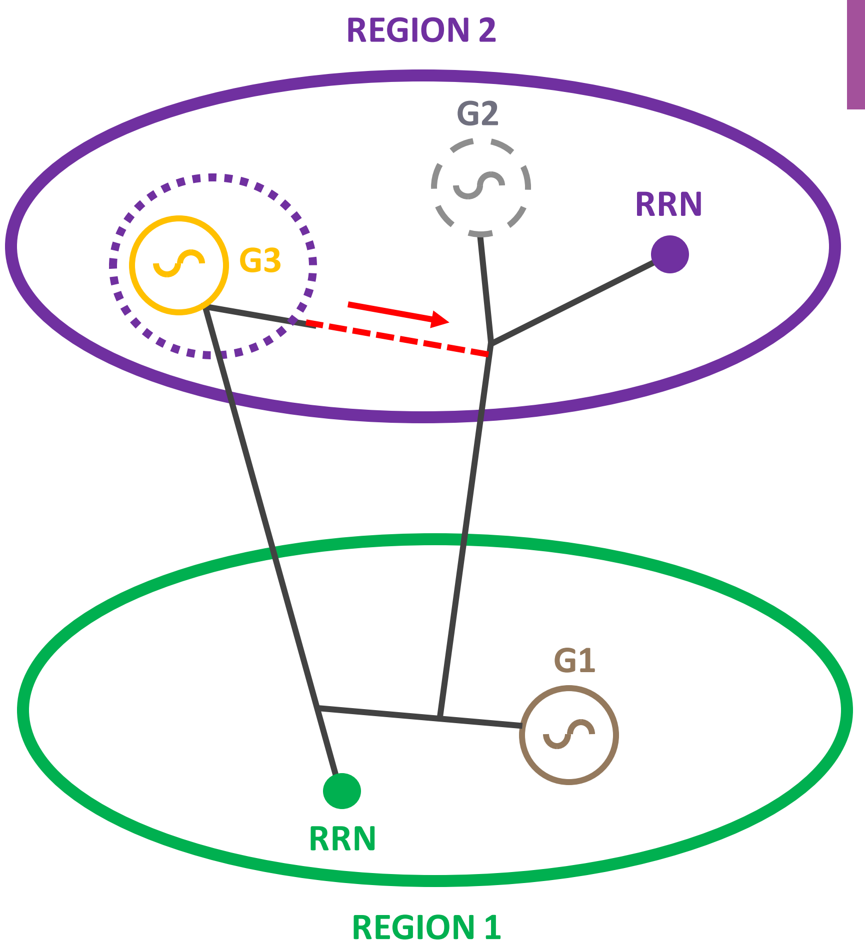
The above indicates that reducing output from G1 and G3 will help relieve the flows and that reducing output from G2 will increase the flows (due to negative distribution factor.



Limits - Example

For simplicity, let's exclude G2 from consideration when managing this intra-regional limit which results in G1 and G3 being the options for management of flow.

As G3 has a materially higher distribution factor, it is more efficient to use (higher impact on flow per MW of reduction).



Supply Exceeds Demand

- Where overall supply exceeds demand, the optimal outcome is to use more expensive generation first.
- In this scenario, the optimal result is to cover the entirety of excess by G1.

Limits - Example

In the following example:

- Line limit = 200MW
- G1 output = 2000MW
- G2 output =1500MW
- G3 output = 50MW

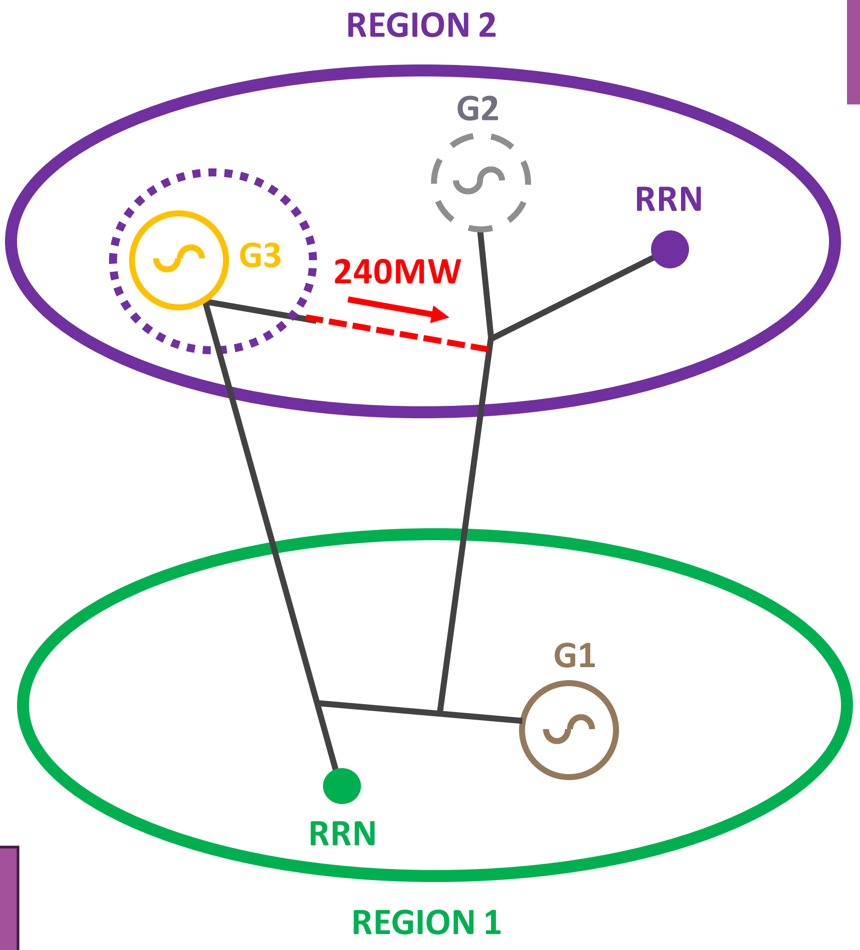
Noting the distribution factors, the 40MW exceedance of the limit can be handled with:

- G1 reduction = 20MW/0.05 = 800MW

Or,

- G3 reduction = 20MW/0.9 = 44.44MW

Note similar can occur where a constraint is fully co-optimised.



Limits – How does this work in reality?

In NEMDE constraint formulation,

- Where a LHS term (distribution factor) is <0.07, the LHS is normalised.
    - Largest factor set to 1, factor applied to RHS to account for normalisation of LHS.
- If LHS terms are <0.07 post normalisation, they are excluded from the LHS of the final constraint equation.
    - Moved to the RHS and no longer an element NEMDE can control when managing the limit.

In linear programming, a controllable element cannot be treated as ‘static’ even in limited circumstances. NEMDE manages representation of the excluded controllable inputs through the use of inputs such as SCADA to represent their impact in the RHS of the equation.

Limits – How does this work in NEMLF?

As per the previous example, an initial observation in NEMLF was that in some circumstances large reductions in remote generation was used to manage relatively small violations of limits.

The core challenge is:

- To accurately determine flows, all material elements required to be considered.
  - Even where distribution factor is small, if generation/load is large can have a material contribution to flow.
- NEMLF does not have access to non-controllable variants of inputs.
  - As mentioned previously, NEMDE has alternative options for representation of controllable elements such as SCADA. This is not an option in NEMLF.

Limits – NEMLF solution

Unconstrained Solution (limits relaxed) → Calculate overloading → Implement constraints to resolve overloading using selected control variables

Limit equation

0.05*G1 - 0.2*G2 + 0.9*G3 + 0.7*G4 + 0.5*Dem_R1 - 0.2*Dem_R2 <= Limit

Unconstrained solution reports

30MW of overloading and Unconstrained Gen MW values

Constraint implemented with only two control variables

$0.9*\Delta G3 + 0.7*\Delta G4 <= -30$

where DG change from unconstrained MW

$\Delta G3 =$ G3 – Unconst_G3

$\Delta G4 =$ G4 – Unconst_G4

Gens with significant positive coefficients selected as control variables.

Extra margin may be required since G1's dispatch can increase in the final run.

BLD_DLP simulated example

CLUSTERID	GENTYPE	GROUP	Limit Coeff	Ratio to largest	Const Coeff
NSW1	HYDRO	INITIAL	-0.00377	0.7%	
NSW_BKH_BRD	HYDRO	INITIAL	0.50859	100.0%	0.50859
NSW_DLP	HYDRO	INITIAL	-0.07504	-14.8%	-0.07504
NSW_FNY_CRA	HYDRO	INITIAL	-0.02919	5.7%	
SA1	HYDRO	INITIAL	0.05562	10.9%	0.05562
SA1	THERMAL	HEADROOM	0.05562	10.9%	0.05562
SA1	THERMAL	INITIAL	0.05562	10.9%	0.05562
VIC1	HYDRO	INITIAL	0.0614	12.1%	0.0614
VIC1	THERMAL	HEADROOM	0.05086	10.0%	0.05086
VIC1	THERMAL	INITIAL	0.05082	10.0%	0.05082
VIC_MUR	HYDRO	INITIAL	0.01051	2.1%	
VIC_RCTS_BATS	HYDRO	INITIAL	0.18664	36.7%	0.18664
VIC_RCTS_BETS	HYDRO	INITIAL	0.29254	57.5%	0.29254

With coefficients < 7% and > -7% (normalised) dropped

Higher threshold can remove more terms

Limits – Why clusters?

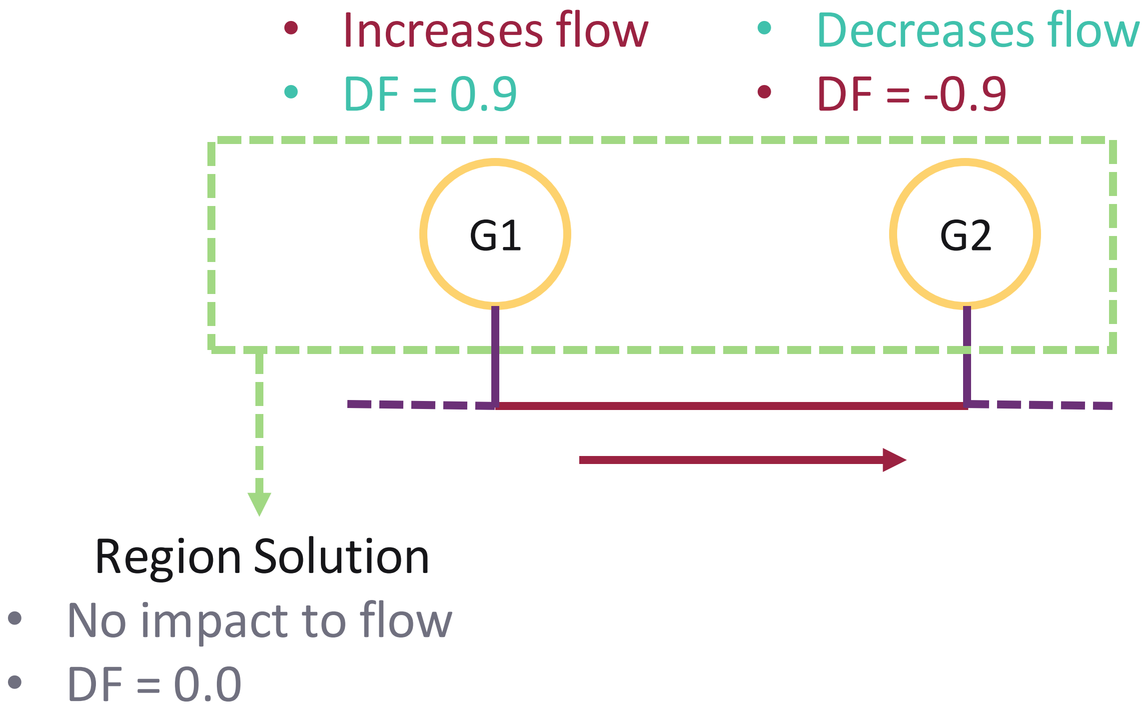
Imagine the scenario to the right, we are trying to limit flows on the line in the direction of the arrow.

If aggregated,

- Distribution factor (DF) = 0
- No ability to manage this limit

If disaggregated (G1 in cluster),

- G1 Cluster DF = 0.9
- Ability to manage this limit.



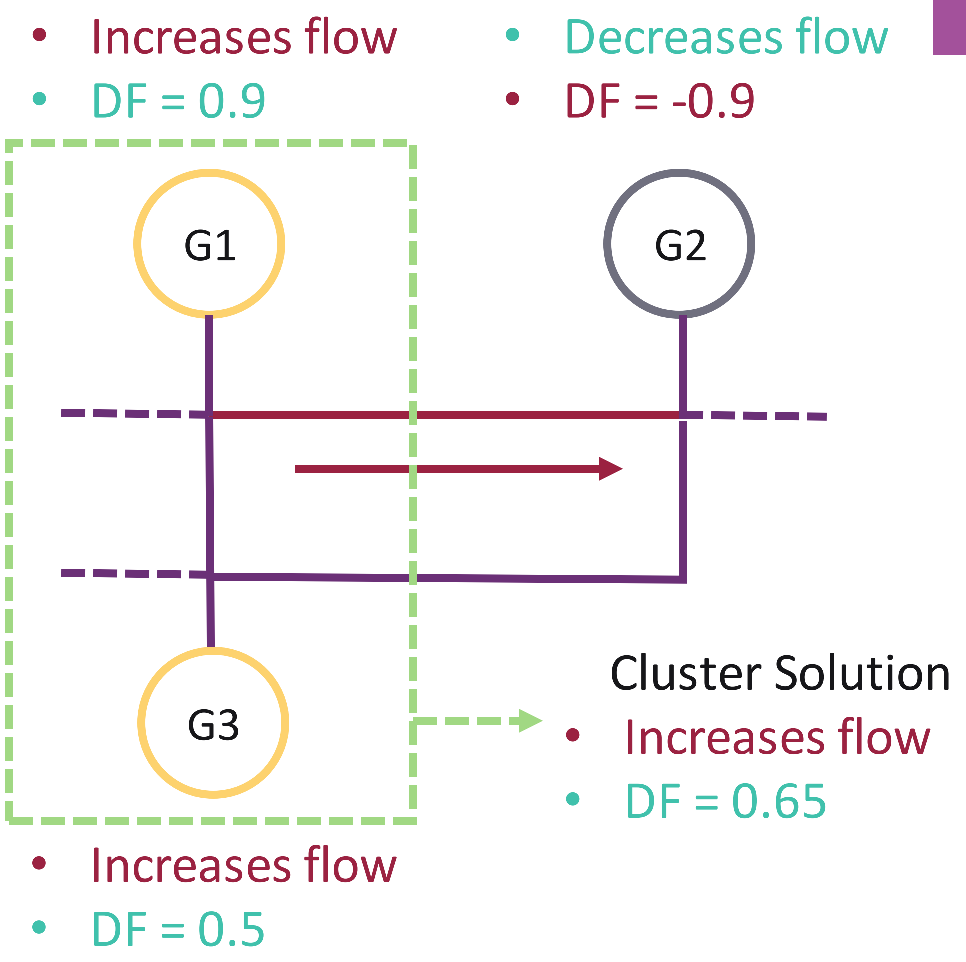
Limits – Why does resolution matter?

If G1 and G3 are aggregated,

- G1 and G3 DF = 0.65 = ((0.9 + 0.5)/2)
- Curtailment smeared over G1, G3.
- Increased curtailment (socialised).
- May reflect outcomes resulting from bid responses to curtailment.

If disaggregated,

- G1 Cluster DF = 0.9
- G2 Cluster DF = 0.5
- G1 prioritised, G2 will not be curtailed until G1 = 0MW.
- Decreased curtailment (no socialisation)



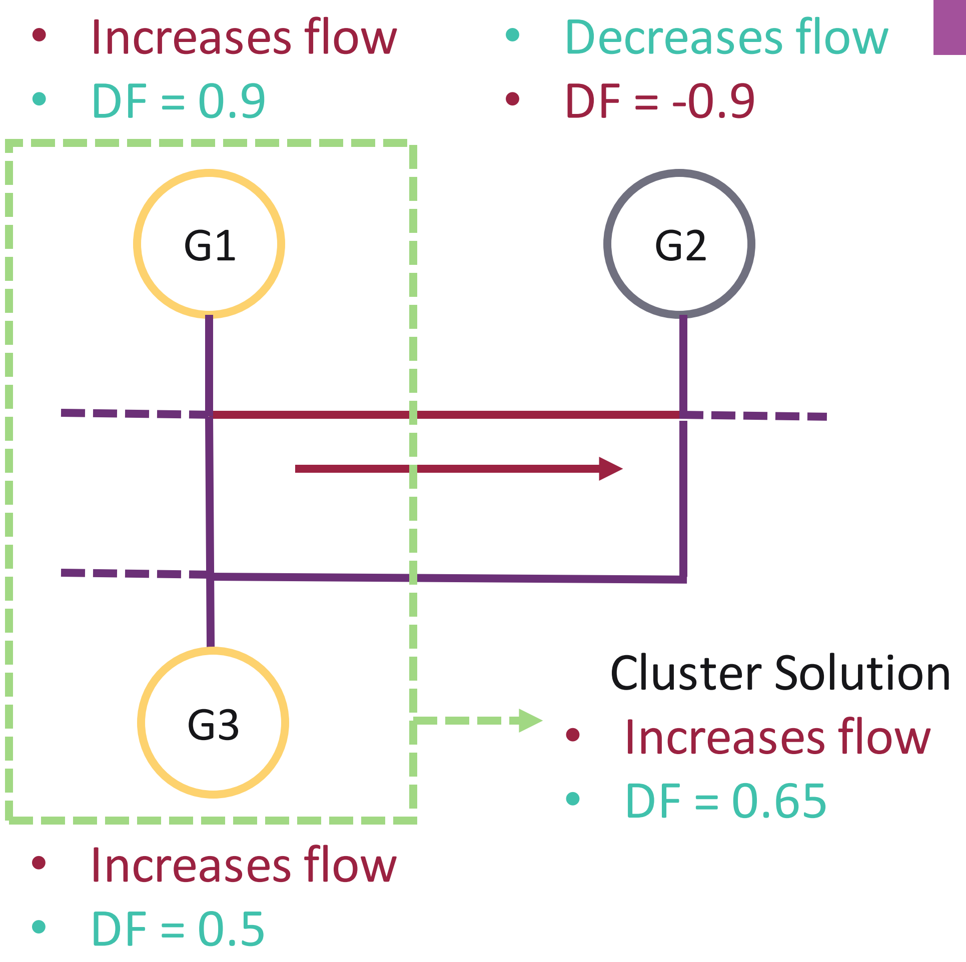
Limits – Why does resolution matter?

If G1 and G3 are aggregated,

- Reflects impact of bidding behaviour, ramp rates, etc.
- Curtailment increased.
- Flow between G3 and G1 decreased.
- Both G1 and G3 have decreased weighting into intervals where curtailment has occurred.
- Positive impact of MLF from curtailment shared.

If disaggregated,

- Does not reflect impact of bidding behaviour.
- Curtailment decreased.
- G1 strong decreased weighting into intervals where curtailment has occurred.
- G1 has increased benefit from curtailment, G2 has decreased benefit.



Supply and demand balancing – Summation of issues

AEMO

Categories – Order of dispatch

- Current terminology is opaque.
- Current terminology increasingly decoupled from reality.
- Full SRMC may not be representative of reality with further decreases in suitability as time progresses.

Limits

- Replication of NEMDE challenging, solution implemented.
- Cluster resolution has an impact on constraint management.
  - Higher resolution
    - Increased efficiency, less reflection of ‘bidding out of constraints’
    - Decreased curtailment.
  - Lower resolution
    - Decreased efficiency. Increased reflection of ‘bidding out of constraints.
    - Increased curtailment.

Supply and demand balancing - Questions

The below details the core elements we are seeking feedback/guidance on, AEMO appreciates these are complex issues and may require both time and further information to be provided prior to stakeholders confirming views.

Categories – Order of dispatch

What are stakeholder views on a revision to the order of dispatch in the supply and demand balancing process?

Limits

What are stakeholder views on the following?

- Cluster resolution.
- Distribution factor cutoff.

New Boundary-point static loss factors section

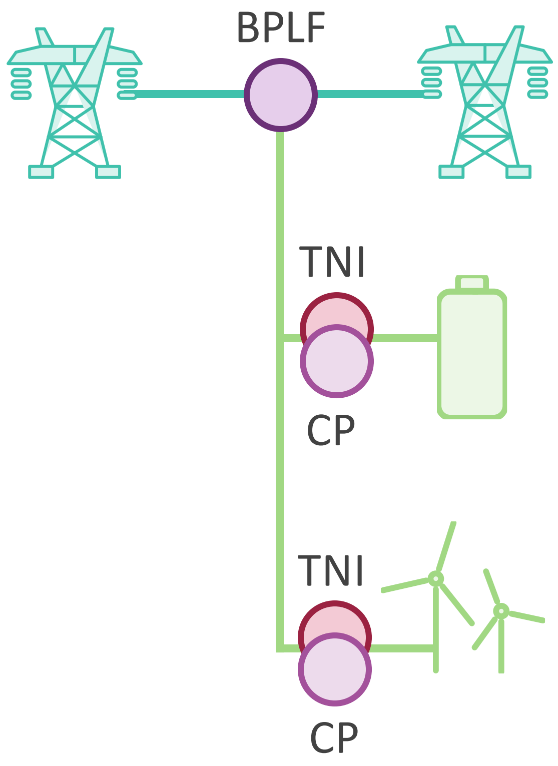
In July 2021, the AEMC made a final determination under the connection to dedicated connection assets (DCA) rule change which introduced designated network assets (DNA).

This change introduced an obligation upon AEMO to determine and publish boundary-point static loss factors (BPLFs).

Boundary point loss factors are intended to allow NSPs to determine the volume of intra-regional residues that accumulate within the DNA without the use of metering and return these residues to parties contracted to fund the DNA.

Boundary-point static loss factors – new section

BPLFs are effectively MLFs determined at the boundary between the DNA and the prescribed transmission network.



Options

- BPLFs to be determined in line with MLF process, with the weighting component using flow at the boundary point.

General Discussion (if time permits)

Please keep the following in mind for this discussion:

- Focus on methodology (priority given to issues resolvable outside the NER).
- Considerate of desire to implement for 2025-26 determination.

Please send feedback to:

MLF_Feedback@aemo.com.au

AEMO

AUSTRALIAN ENERGY MARKET OPERATOR

For more information visit

aemo.com.au