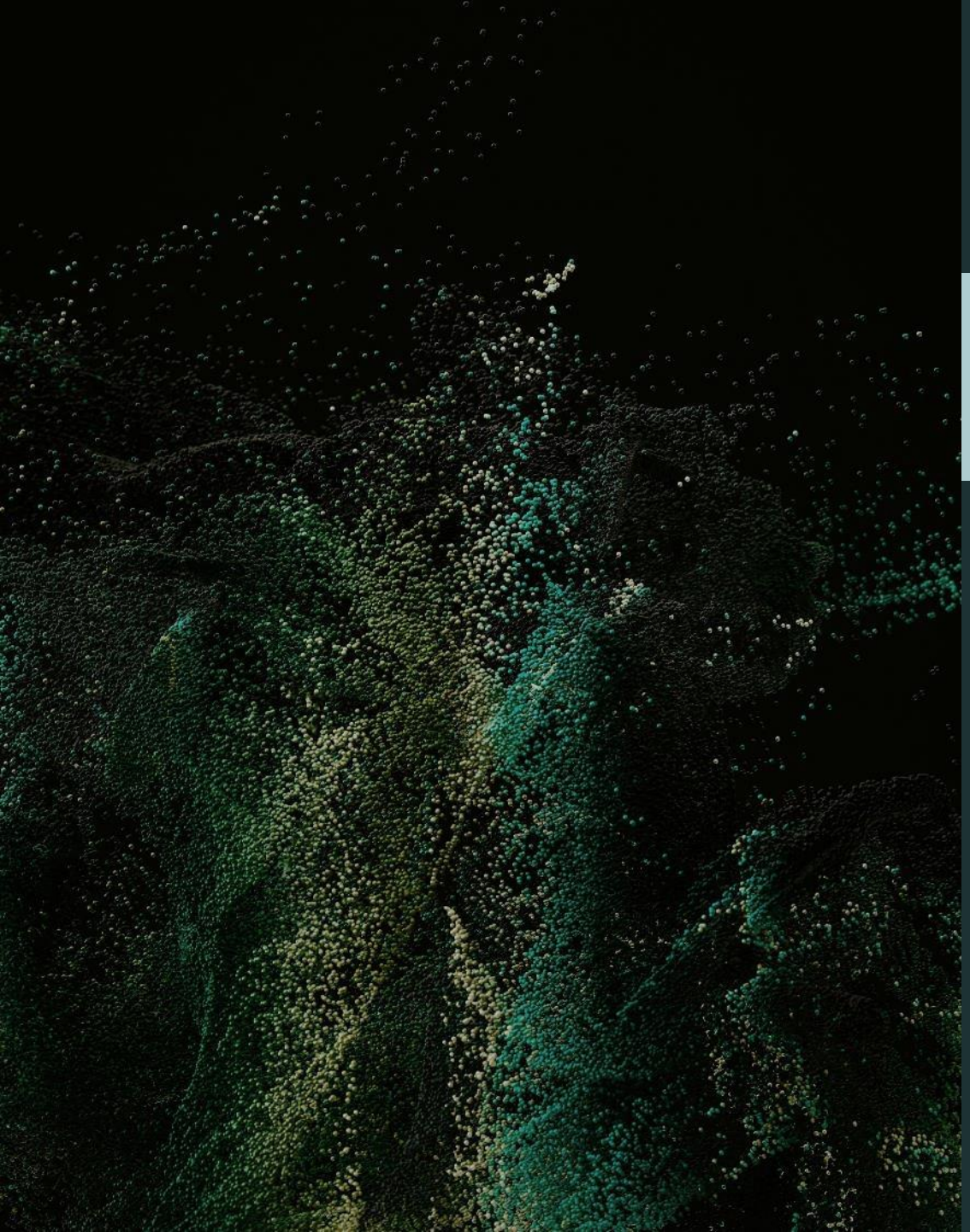


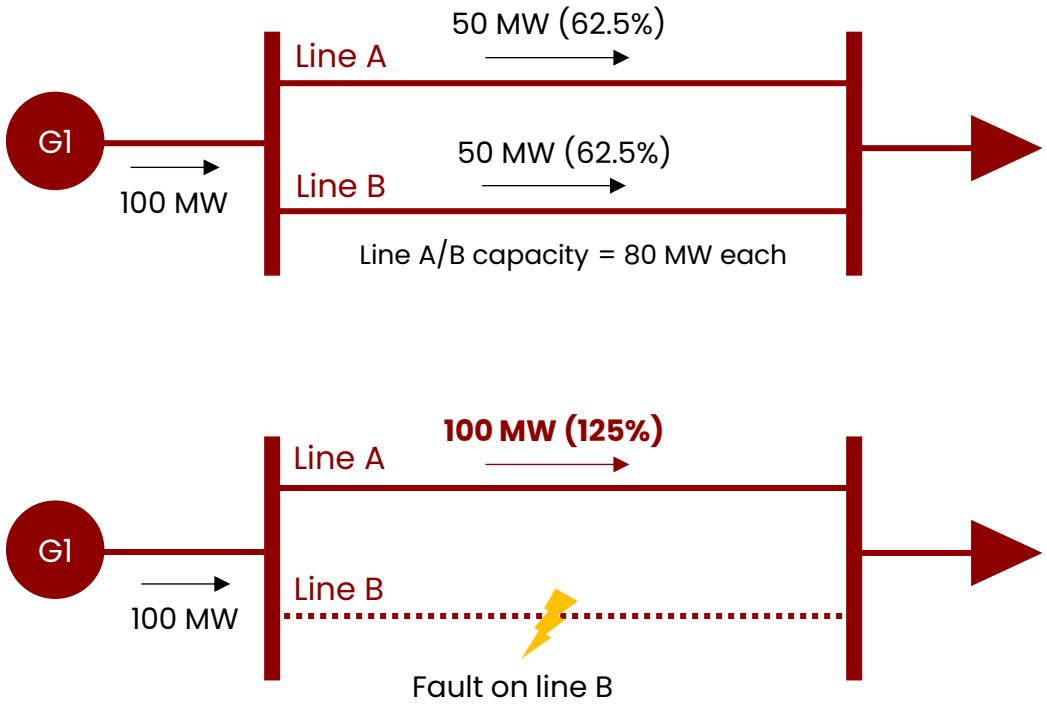
Analysis of WEM Congestion

A “how and why” of the most binding System Normal constraints in the WEM in Capacity Year (CY) 2024-25

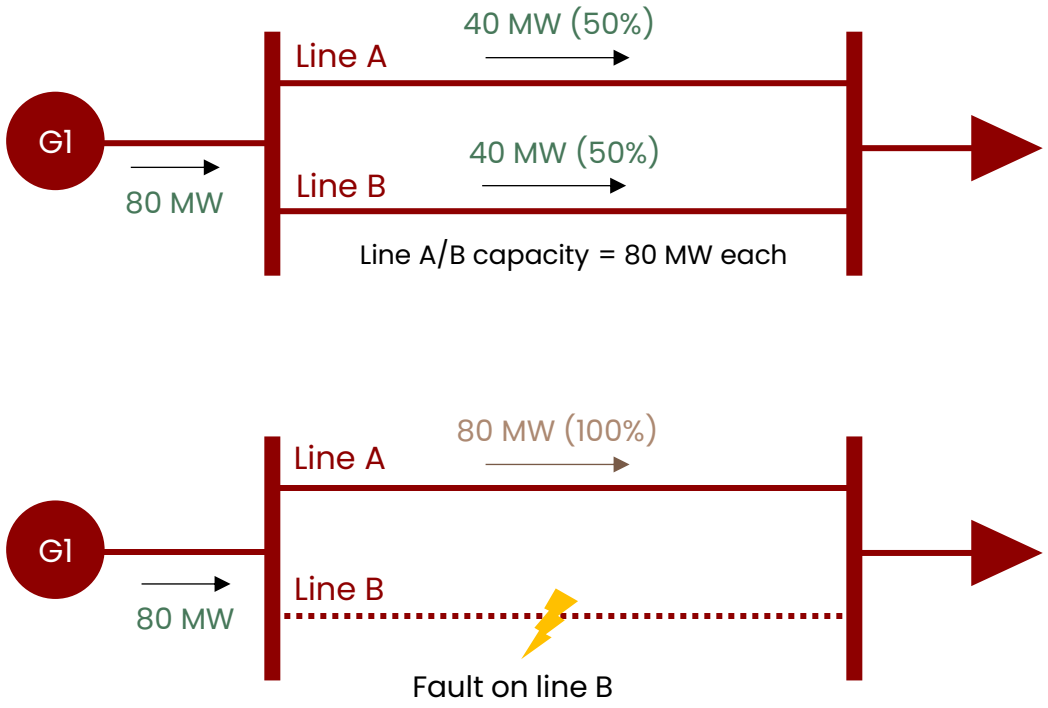
11 June 2026

Facilities in the WEM are dispatched to maintain N-1 system security

N-1 security refers to the power system operating within its limits (e.g. no thermal overloads and remains stable) after a single credible contingency on a network element (e.g. loss of a line, transformer, generator, etc).



N-1 insecure dispatch



N-1 secure dispatch (but congested)

We will look at the most binding System Normal thermal constraints in CY 2024-25

The most binding System Normal (NIL) thermal constraints are published in the AEMO 2025 WEM Annual Congestion Report (for the period from 01/10/2024 08:00 to 01/10/2025 07:55).

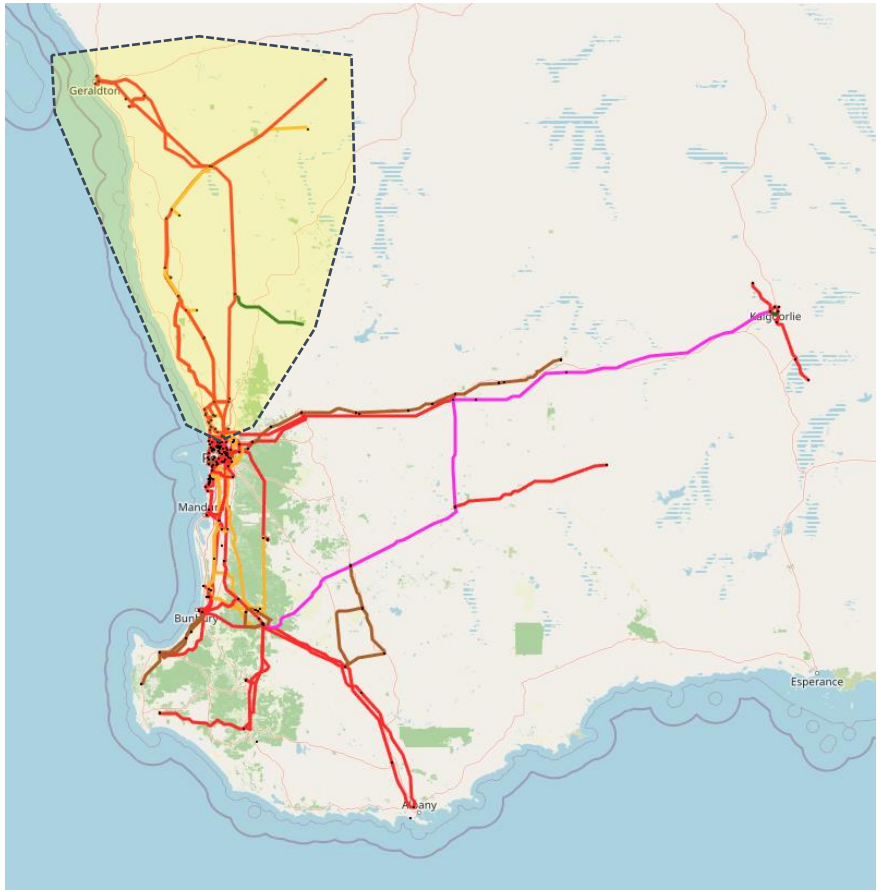
A selection of these constraints are examined in this presentation:

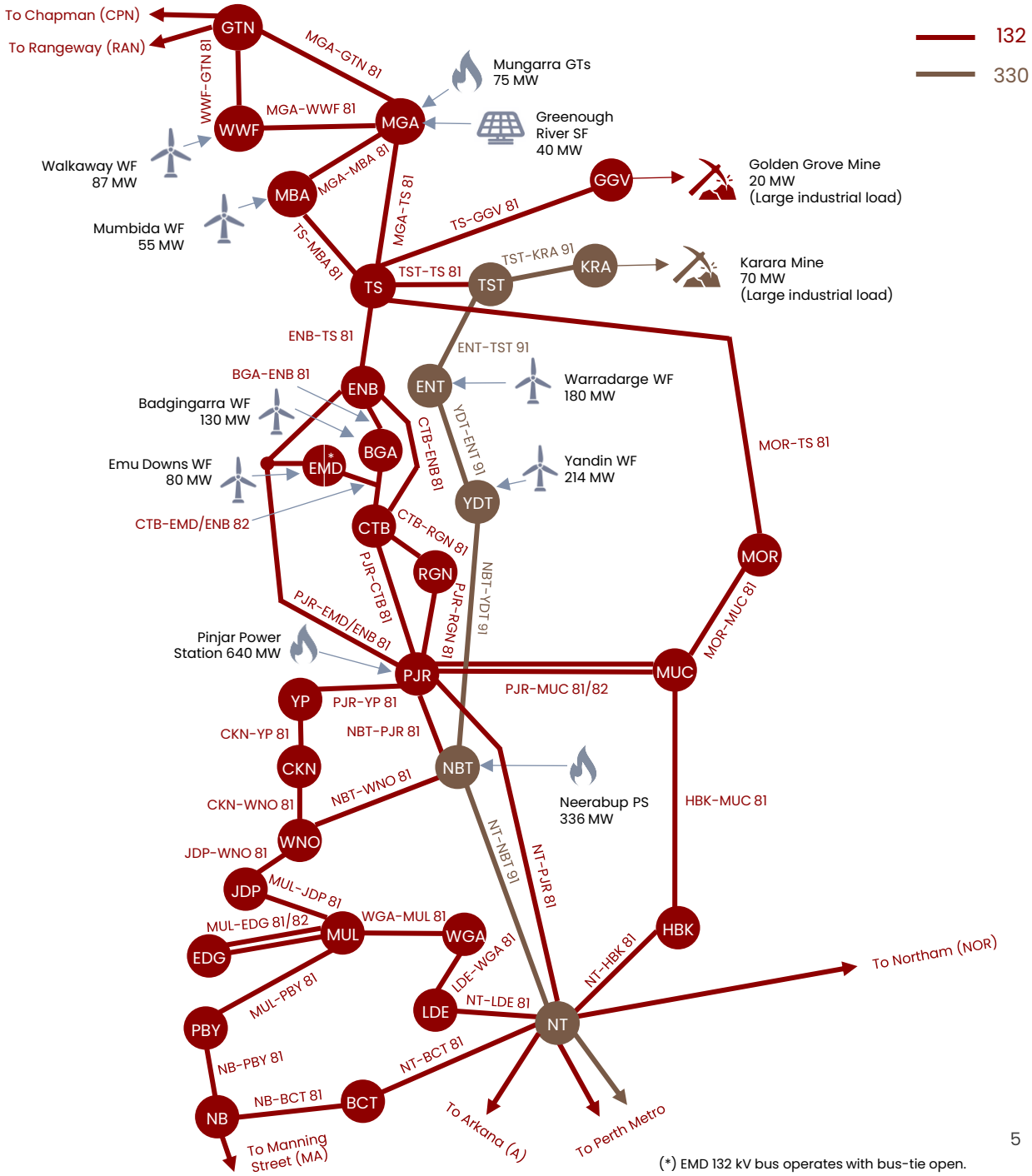
Area	Constraint ID	Type	Binding/violating intervals	Total shadow price
North	NIL > {PJR-CTB 81} [PJR-RGN 81 (RGN~)]	Thermal	2895 (2.75%)	$707,637
North	NIL > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]	Thermal	422 (0.40%)	$344,617
North	NIL > {TST-TS 81} [PJR-RGN 81 (RGN~)]	Thermal	56 (0.05%)	$3,979
South	NIL > {MBR-ALB 81} [KOJ81-KAF (KOJ-)]	Thermal	2369 (2.25%)	$389,112
Metro South	NIL > {KW-CC-MED 81} [WM81-RWA (WM~)]	Thermal	38 (0.04%)	$236,850

Note: there were a series of binding constraints related to overloading of the MU-NGS X1 line, but the capacity on this line was upgraded in May 2025, which has largely addressed the issue.

.01
North Region

North region network topology



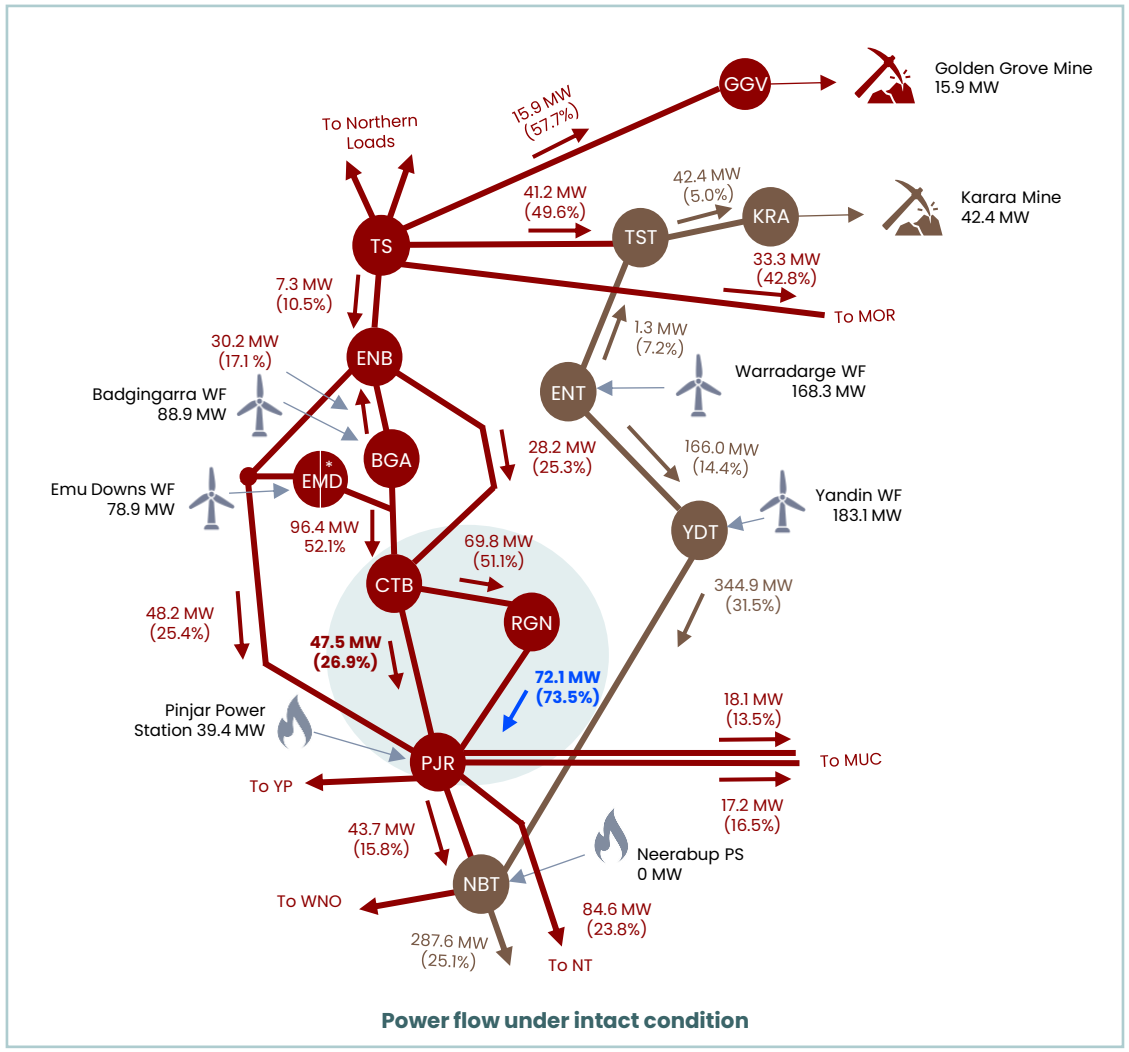


(*) EMD 132 kV bus operates with bus-tie open.

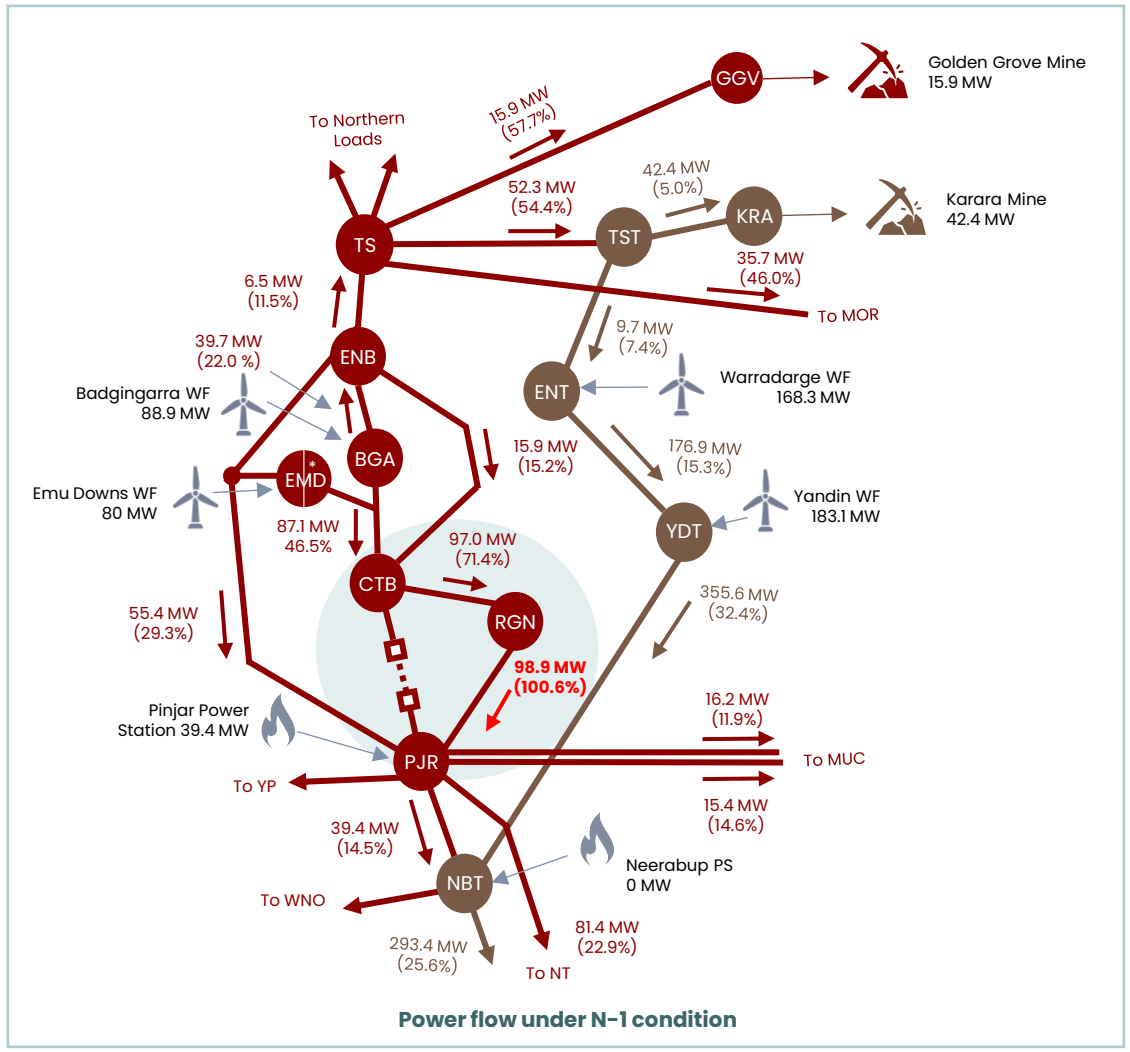
Constraint: NIL > {PJR-CTB 81} [PJR-RGN 81 (RGN~)]

Overload of PJR-RGN 81 line on trip of PJR-CTB 81 line

Indicative power flow simulation for 12/02/2025 at 18:00



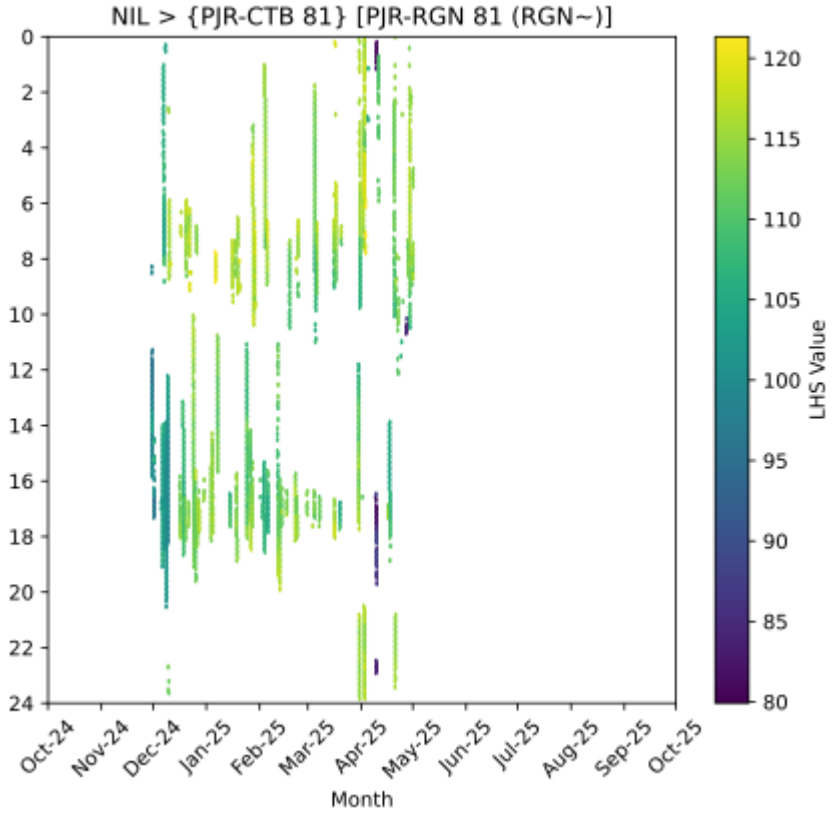
Power flow under intact condition



Power flow under N-1 condition

Constraint: NIL > {PJR-CTB 81} [PJR-RGN 81 (RGN~)]

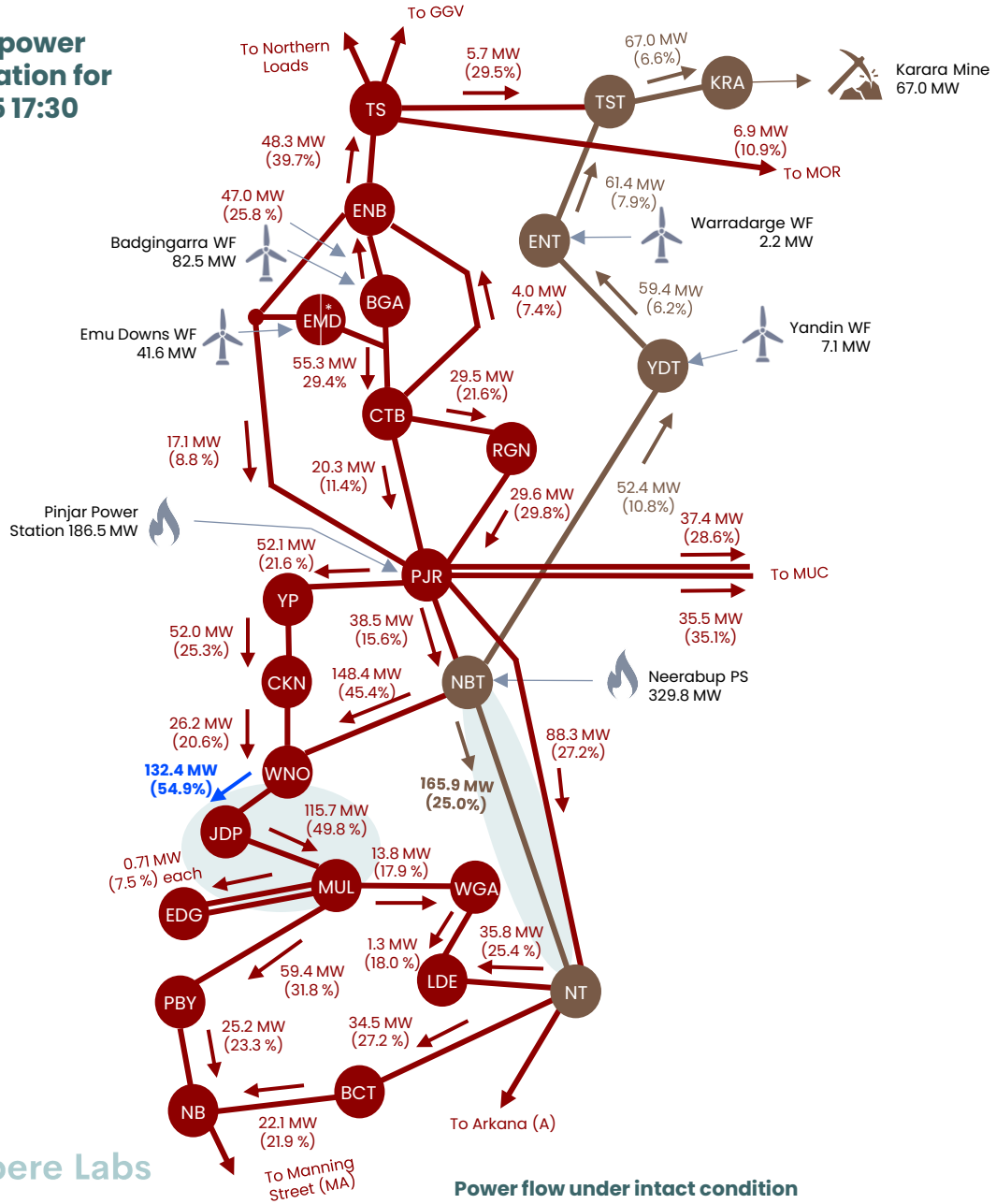
- This constraint deals with the **overload of the PJR-RGN 81 line** on the **trip of PJR-CTB 81** (both 132 kV lines).
- This constraint commonly binds during intervals where there is **high wind output** in the Mid West area, resulting in **southward flows** towards the Perth Metro area.
- The constraint was the most binding System Normal constraint in the CY 2024-25 (binding 2.75% of all intervals).
- The constraint frequently bound across the day between Nov-24 and May-25. This also broadly aligns with the change from Summer to Winter line ratings. The Summer and Winter ratings for PJR-RGN 81 are 98 MVA and 135 MVA respectively.



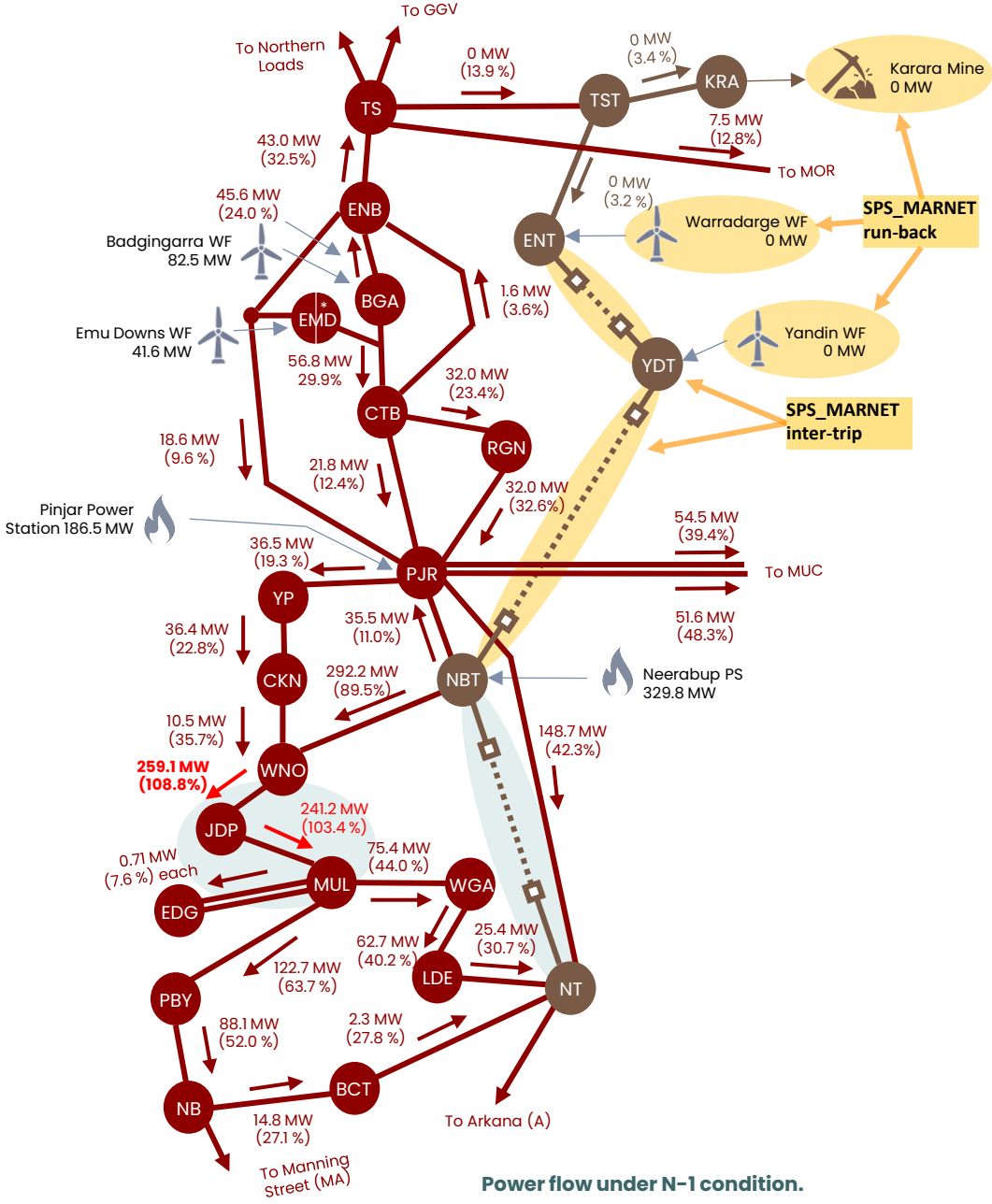
Constraint: NIL > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]

Overload of JDP-WNO 81 line on trip of NBT-NT 91 line + MARNET scheme operation

Indicative power flow simulation for 27/03/2025 17:30



Power flow under intact condition

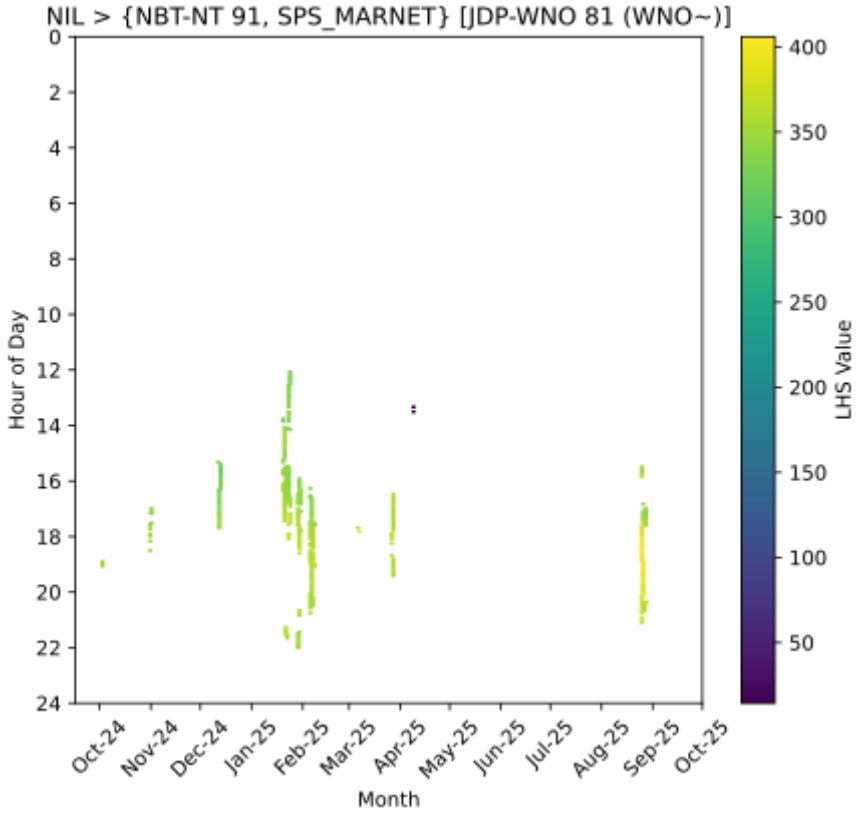


Power flow under N-1 condition.

Ampere Labs

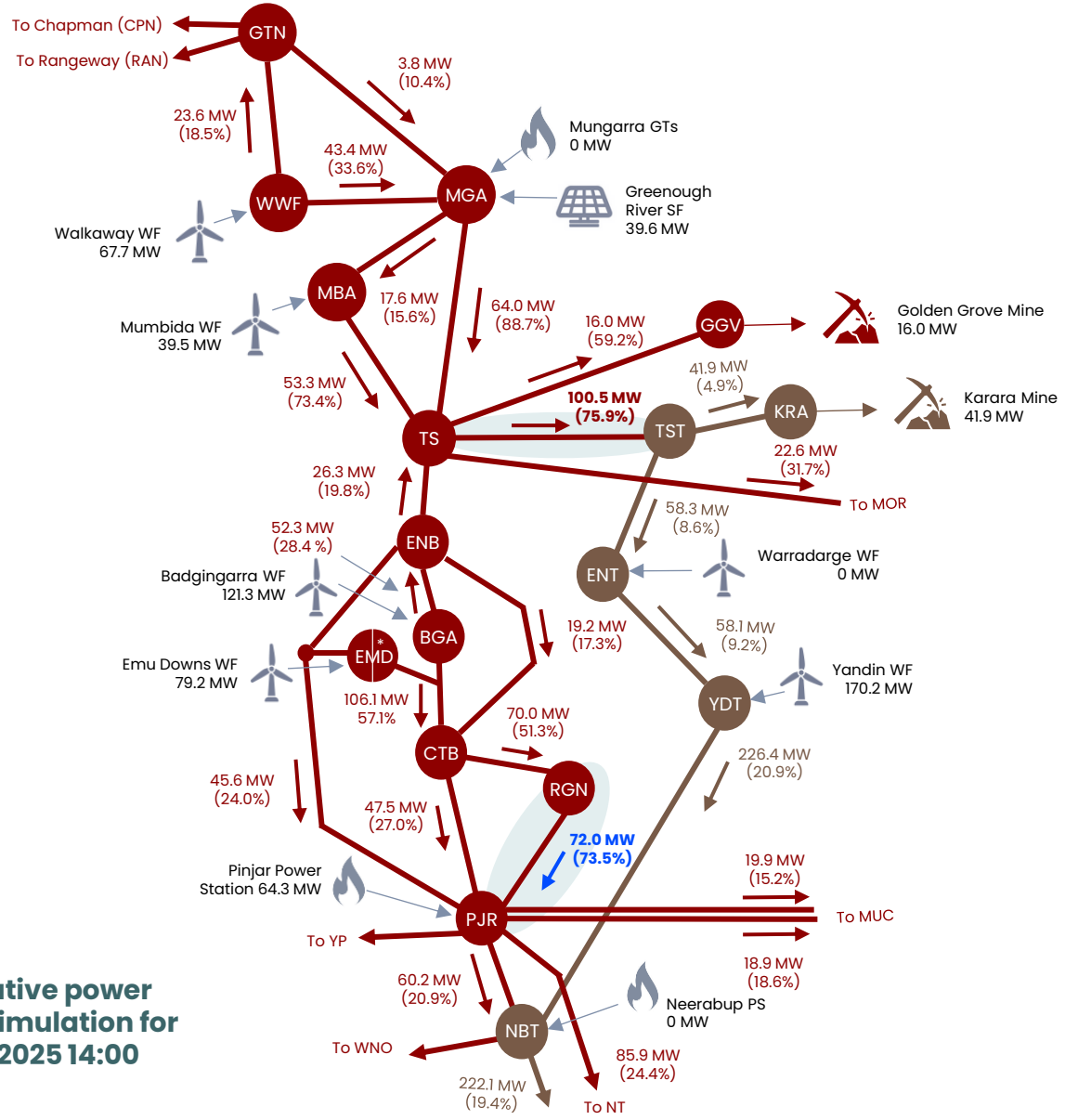
Constraint: NIL > {NBT-NT 91, SPS_MARNET} [JDP-WNO 81 (WNO~)]

- This constraint deals with the **overload of the JDP-WNO 81 line (132 kV)** on the **trip of NBT-NT 91 (330 kV) and the operation of a special protection scheme (SPS)**.
- This constraint binds during afternoon/evening peak intervals (0.4% of all intervals) where Neerabup Power Station output is high and the trip of the NT-NBT 91 would result in southward flows on the 330 kV line being re-routed into the 132 kV North Metro meshed loops (NBT-WNO-JDP-MUL).



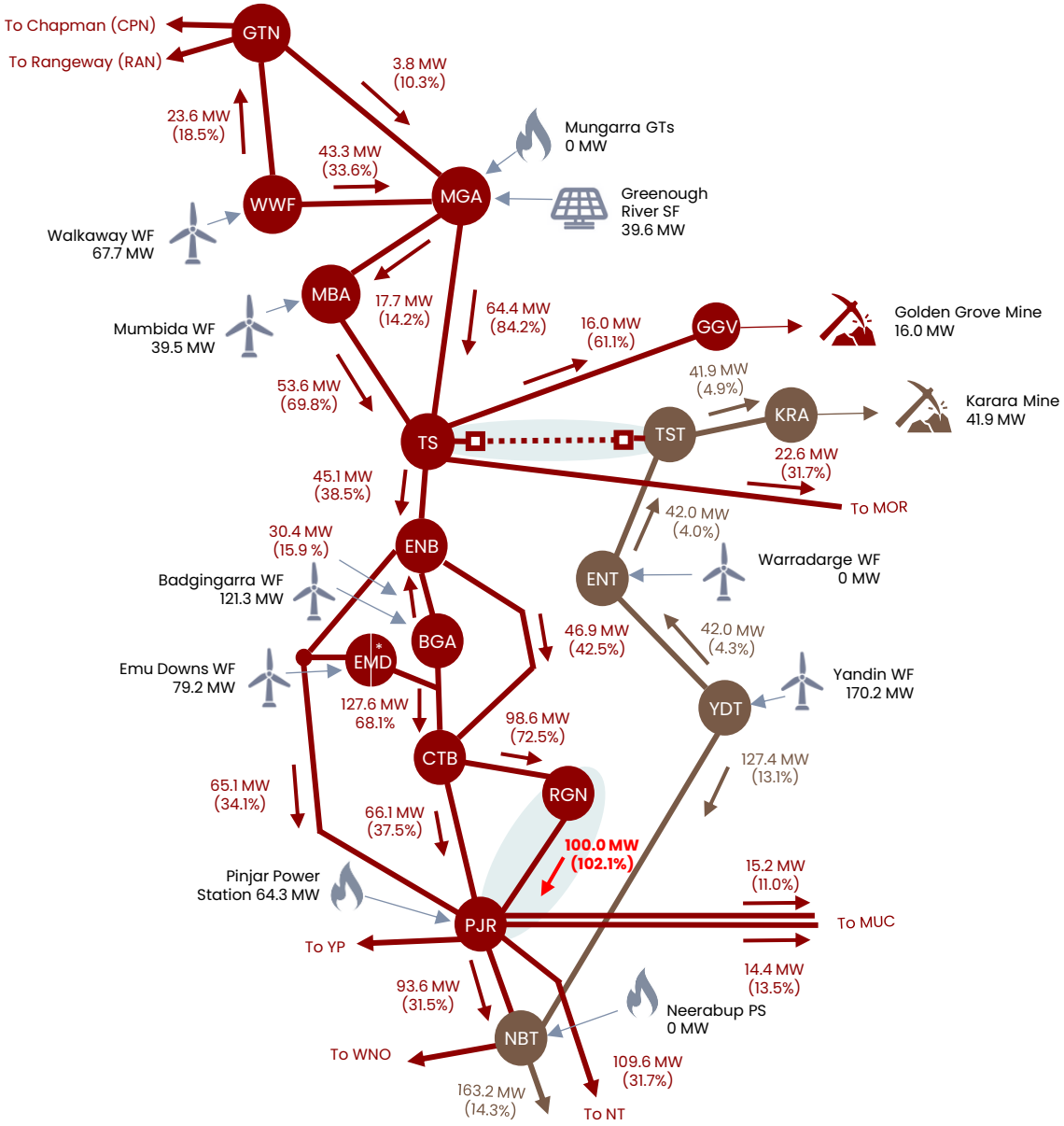
Constraint: NIL > {TST-TS 81} [PJR-RGN 81 (RGN~)]

Overload of PJR-RGN 81 line on trip of TST-TS 81 line



Indicative power flow simulation for 11/02/2025 14:00

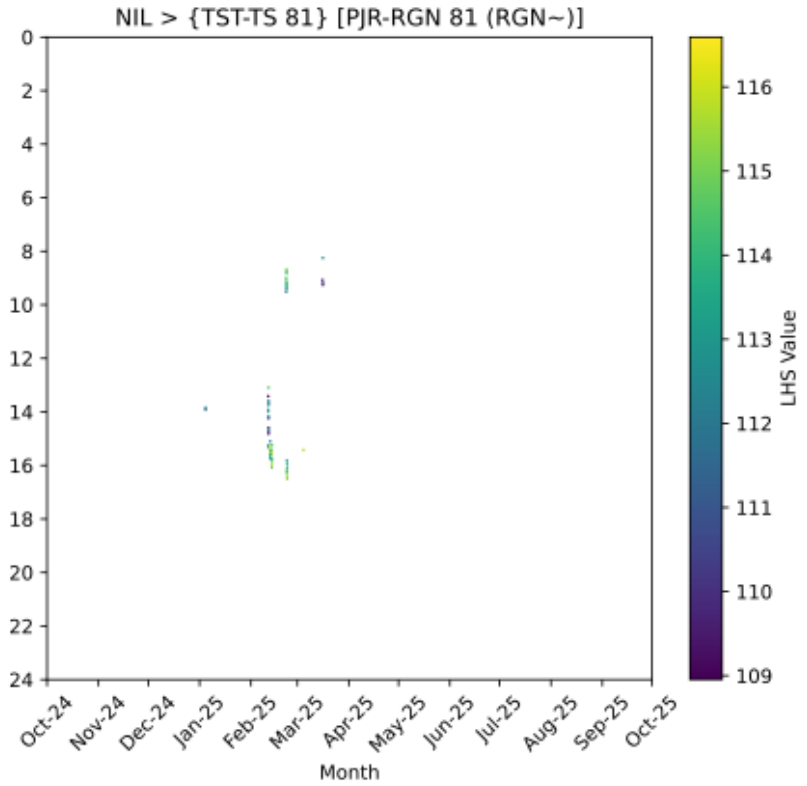
Power flow under intact conditions



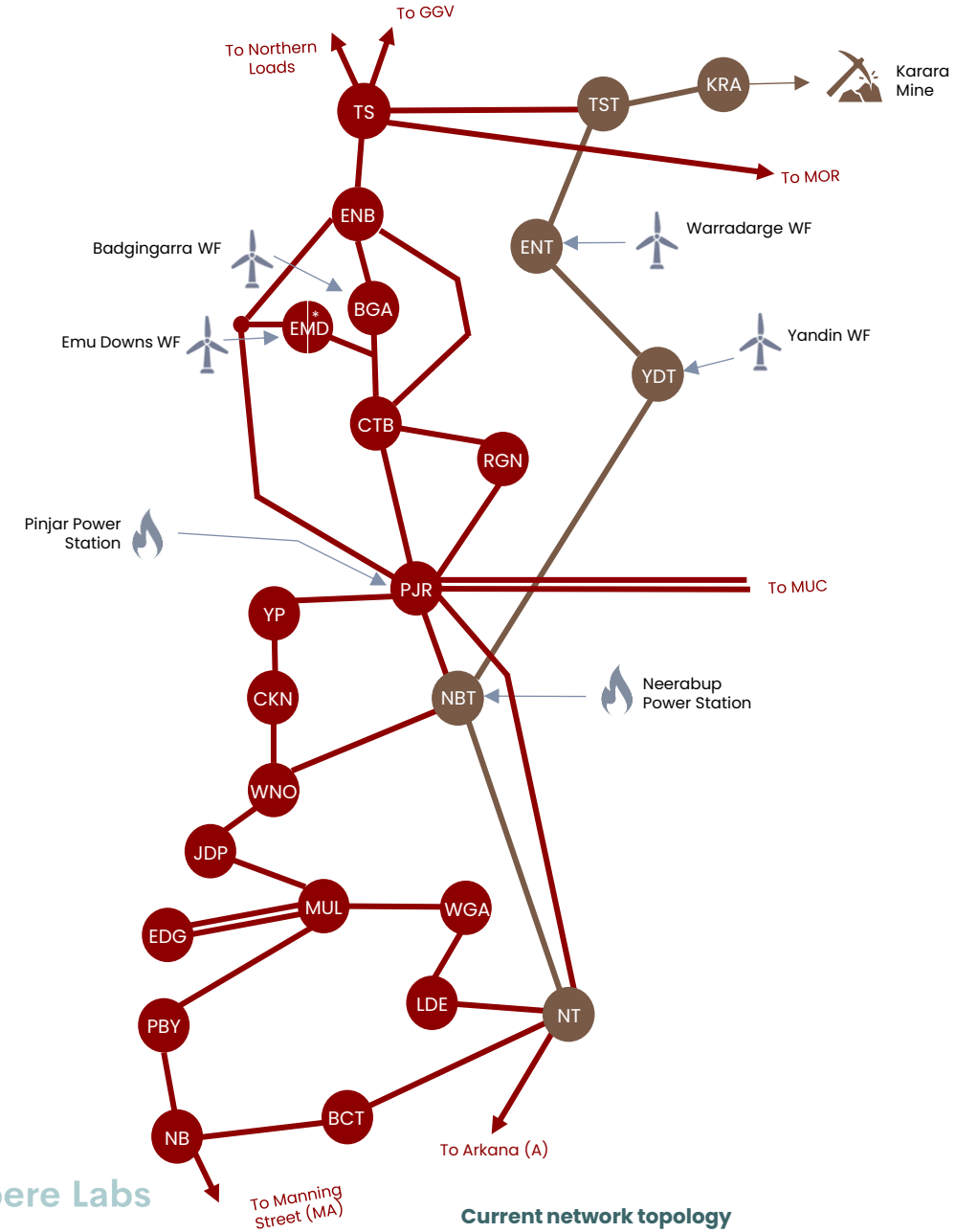
Power flow under N-1 conditions.

Constraint: NIL > {TST-TS 81} [PJR-RGN 81 (RGN~)]

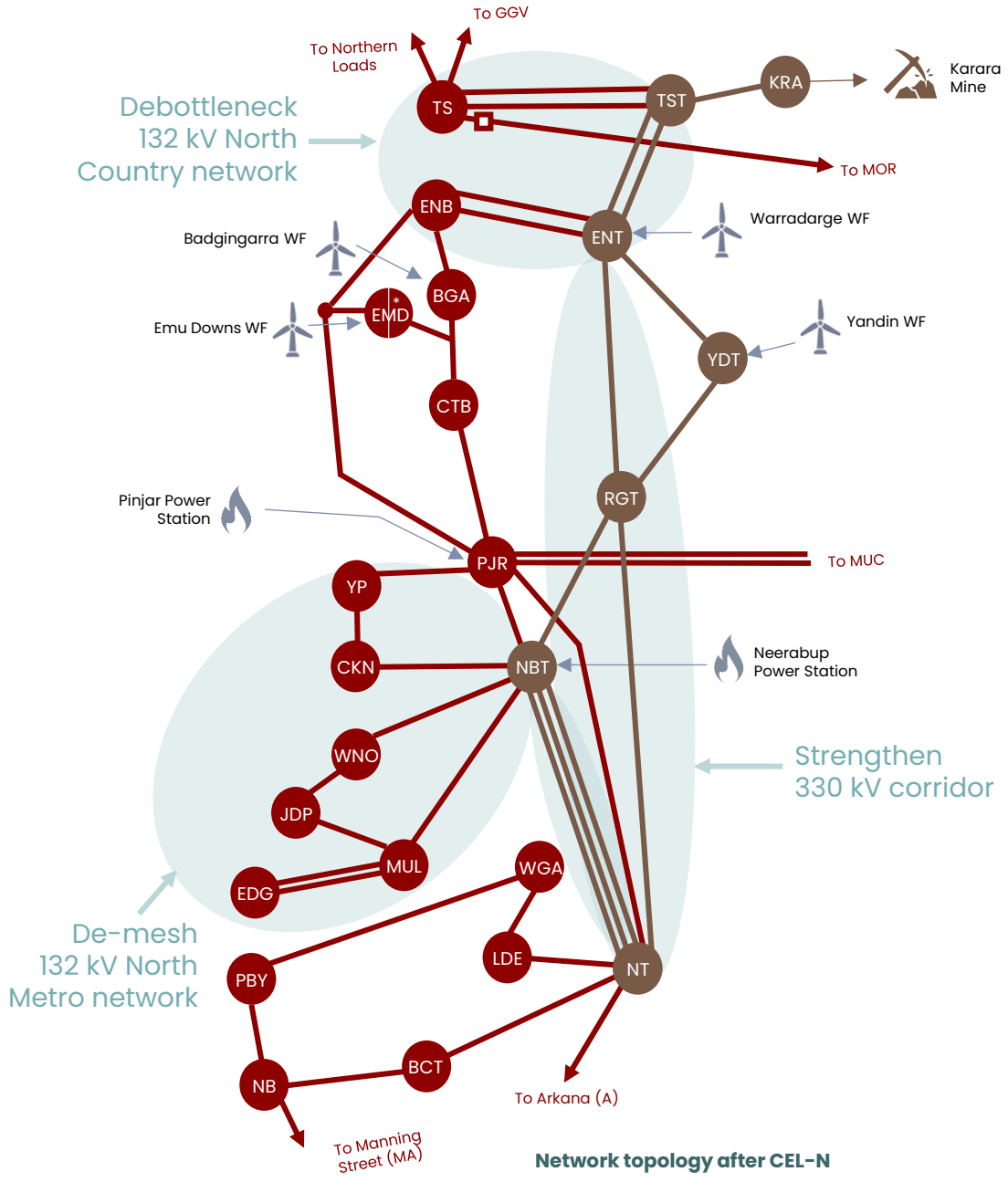
- This constraint deals with the **overload of the PJR-RGN 81 line** on the **trip of TST-TS 81** (both 132 kV lines).
- This constraint only binds under the following relatively uncommon circumstances:
    - North Country generation is high
    - Mid West wind generation is high
    - North Country demand at Geraldton is relatively low
- These conditions result in a **high TST-TS 81 flow** and southward flow along the 330 kV transmission corridor. On trip of the TST-TS 81 line, this southbound power flow is re-directed into the 132 kV network. Coupled with already high utilisation due to Mid West wind generation, the PJR-RGN 81 line can be overloaded.



Clean Energy Link – North (CEL-N) will alleviate these constraints



Current network topology



Network topology after CEL-N

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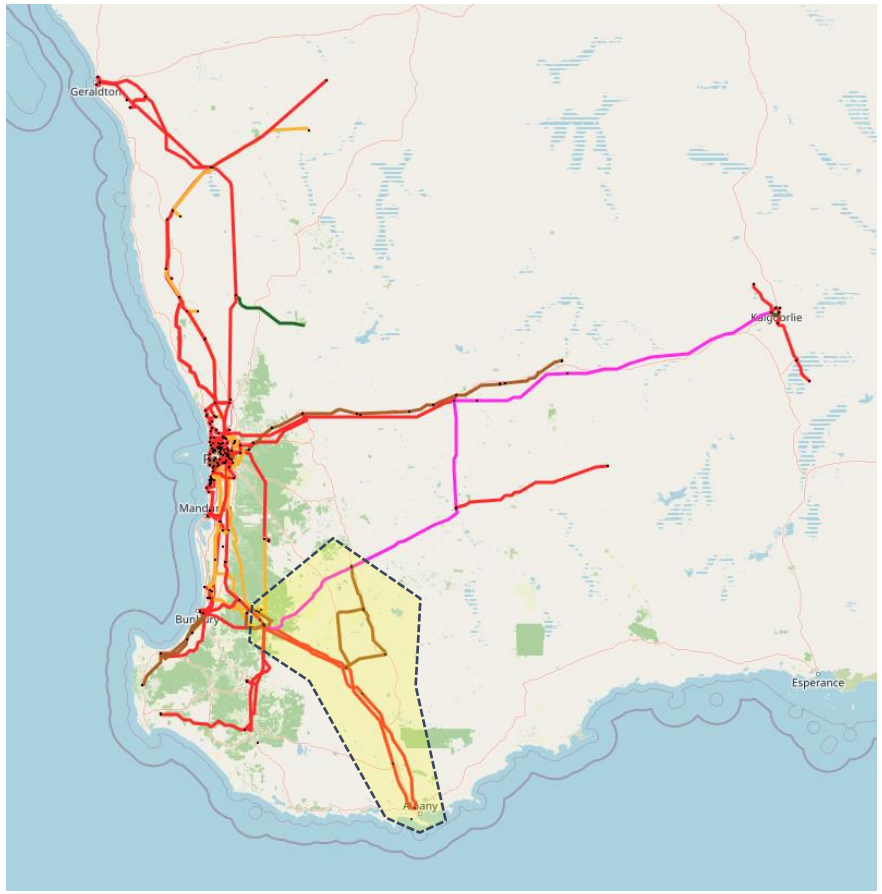
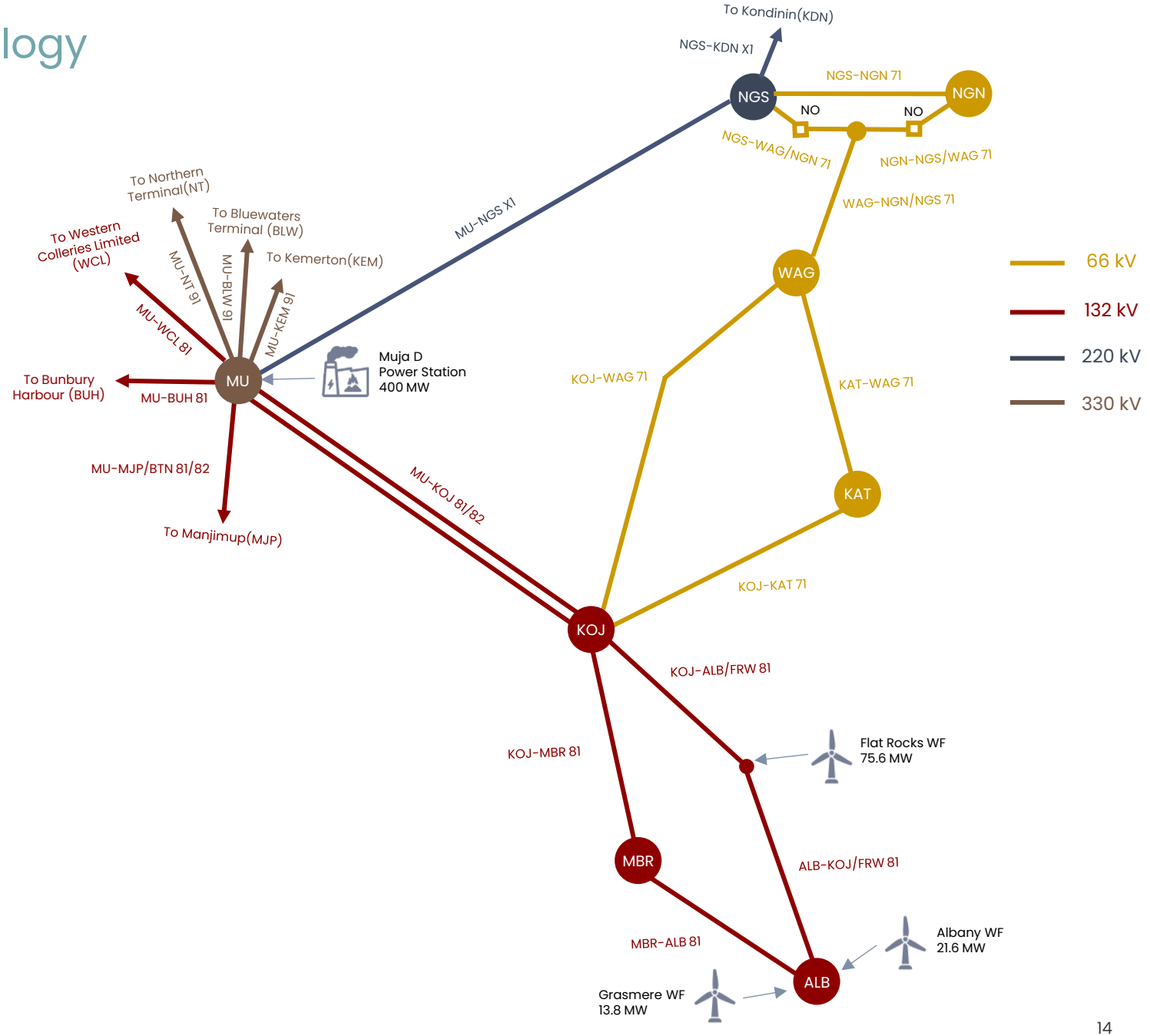
.02
South Region

Great Southern region network topology

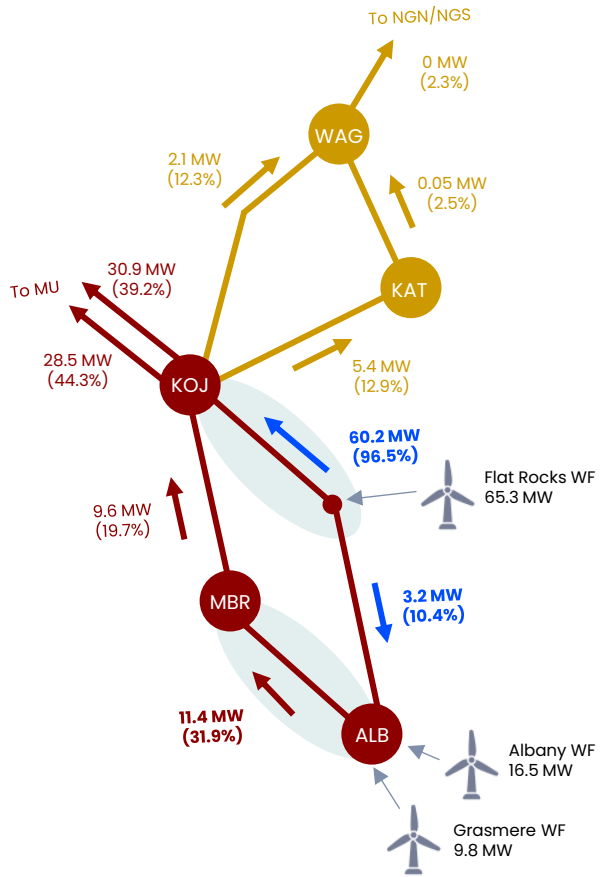




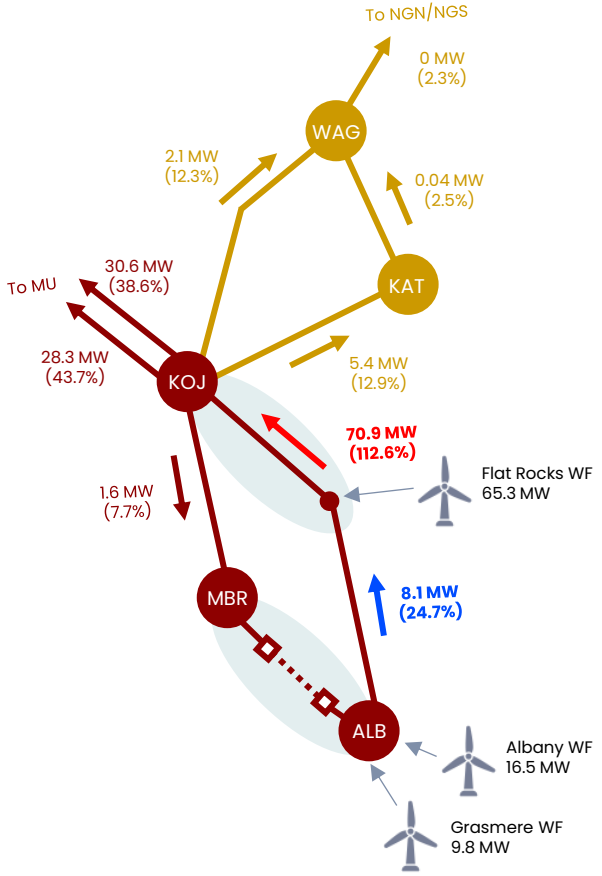
Constraint: NIL > {MBR-ALB 81} [KOJ81-KAF (KOJ-)]

Overload of KOJ-ALB/FRW 81 line on trip of MBR-ALB 81 line

Indicative power flow simulation for 07/01/2025 04:00



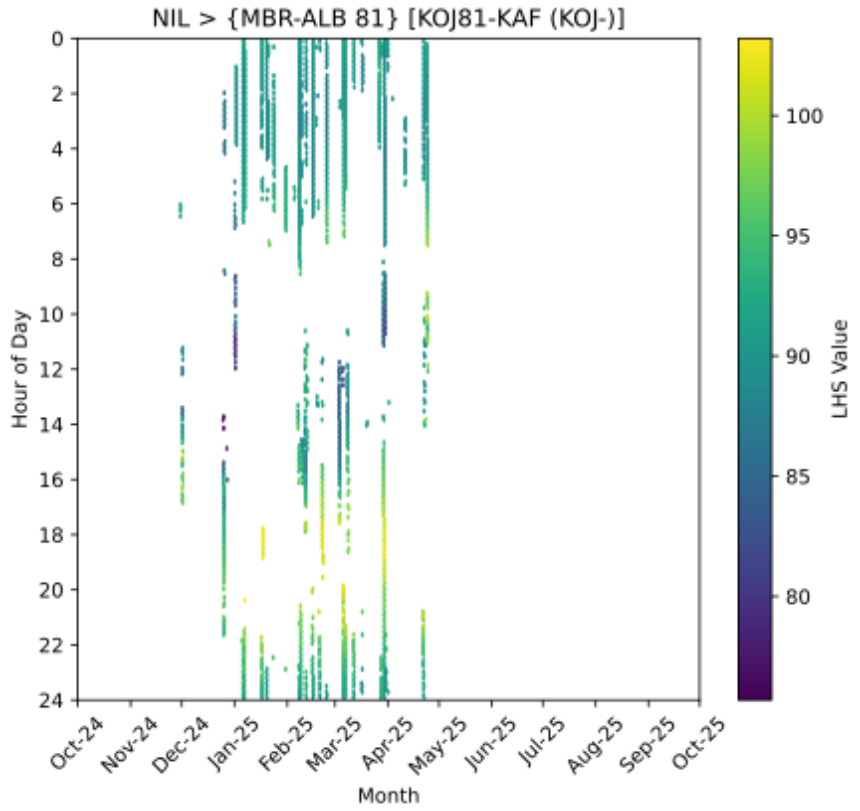
Power flow under intact condition



Power flow under N-1 condition

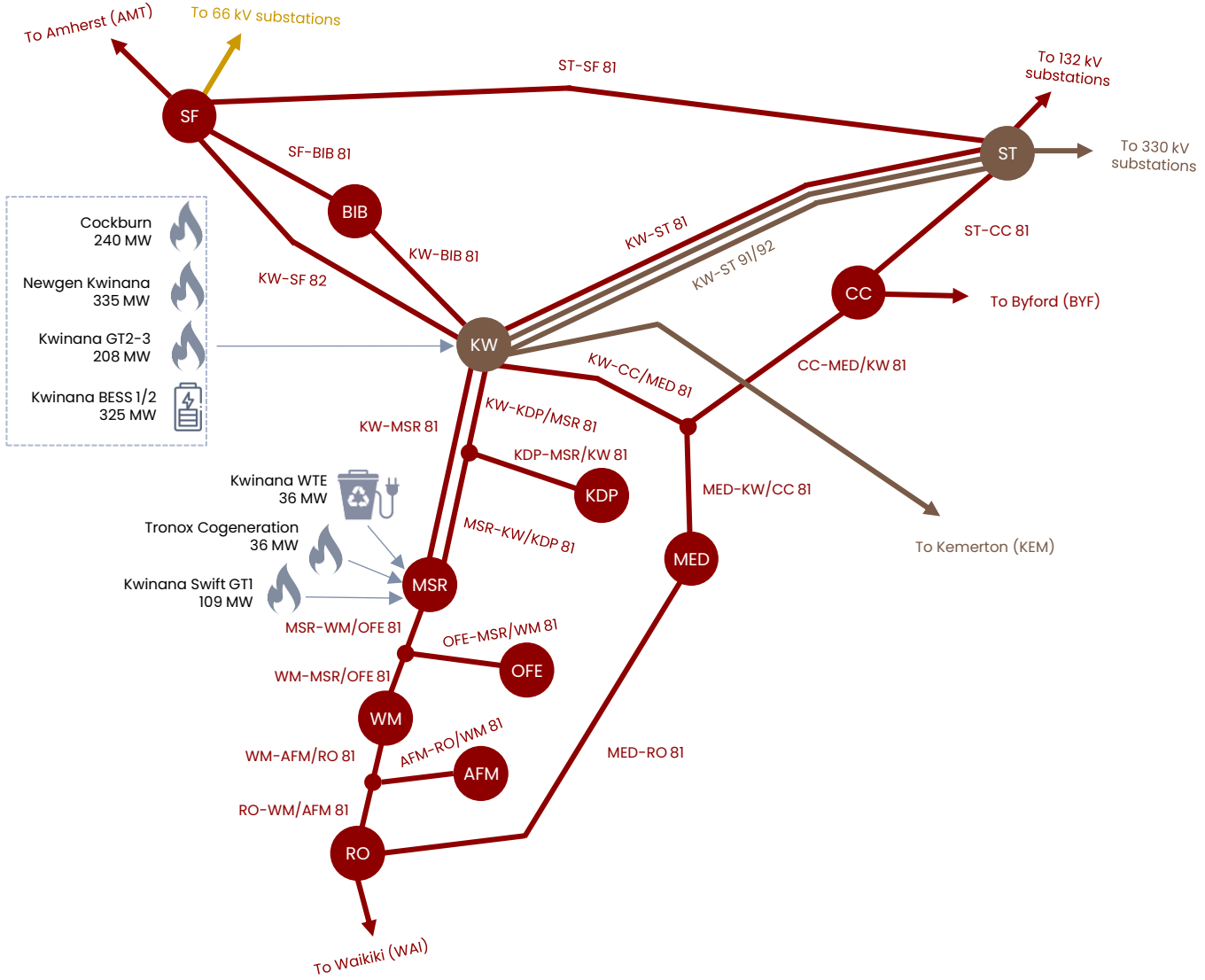
Constraint: NIL > {MBR-ALB 81} [KOJ81-KAF (KOJ-)]

- This constraint deals with the **overload of the KOJ-ALB/FRW 81 (KAF) line** on the **trip of MBR-ALB 81 line** (all 132 kV lines).
- This constraint commonly binds during intervals where there is **high wind output** from Flat Rocks WF, particularly at lower load (e.g. overnight or early morning), resulting in **northward flows** towards Muja.
- The constraint was the most binding in the South region for CY 2024-25.
- The constraint frequently bound across the day between Nov-24 and May-25. This also broadly aligns with the change from Summer to Winter line ratings. The Summer and Winter ratings for KOJ-ALB/FRW 81 are 338 MVA and 472 MVA respectively.



.03
Metro South Region

Metro South region network topology†

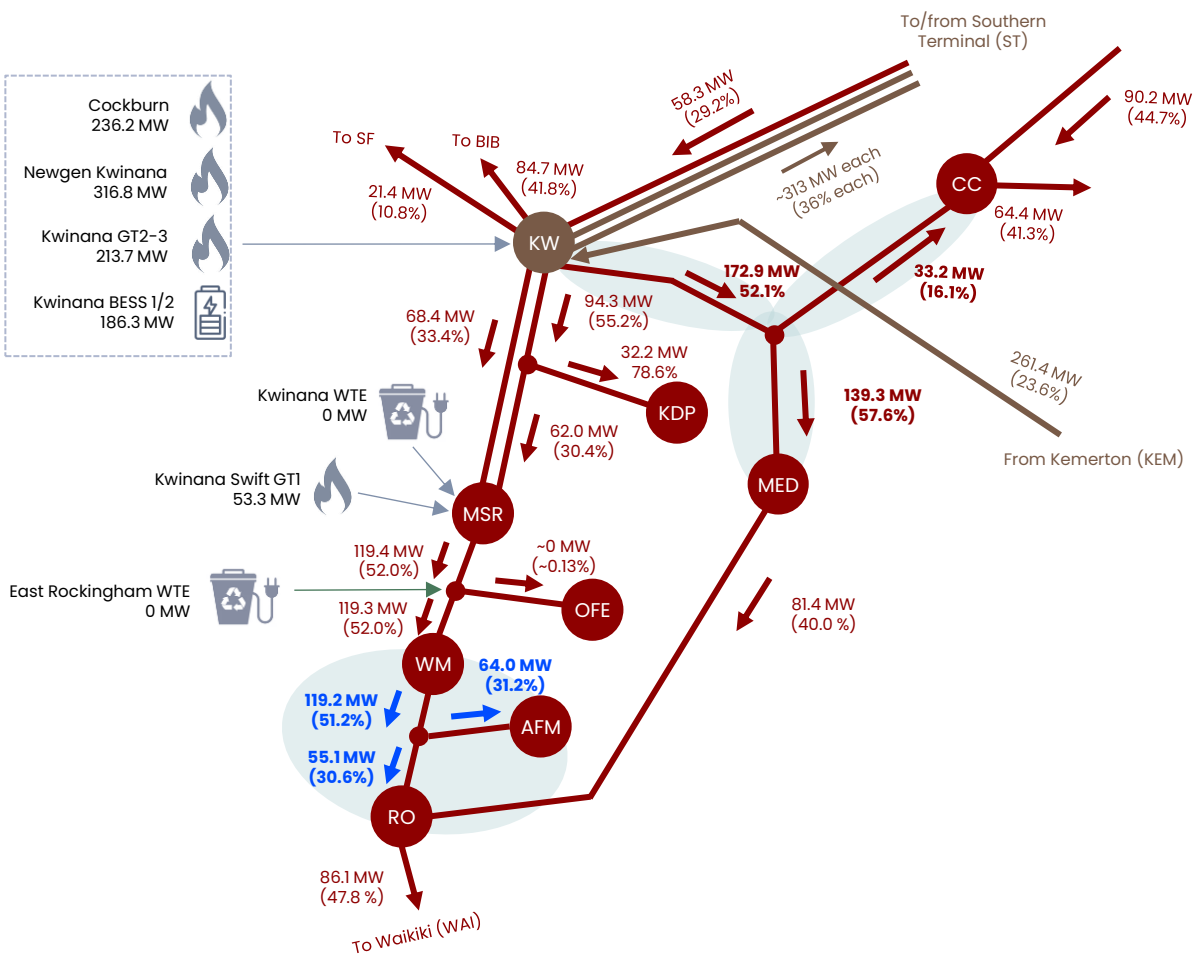


† Topology simplified to aid interpretation due to the area's significant meshing.

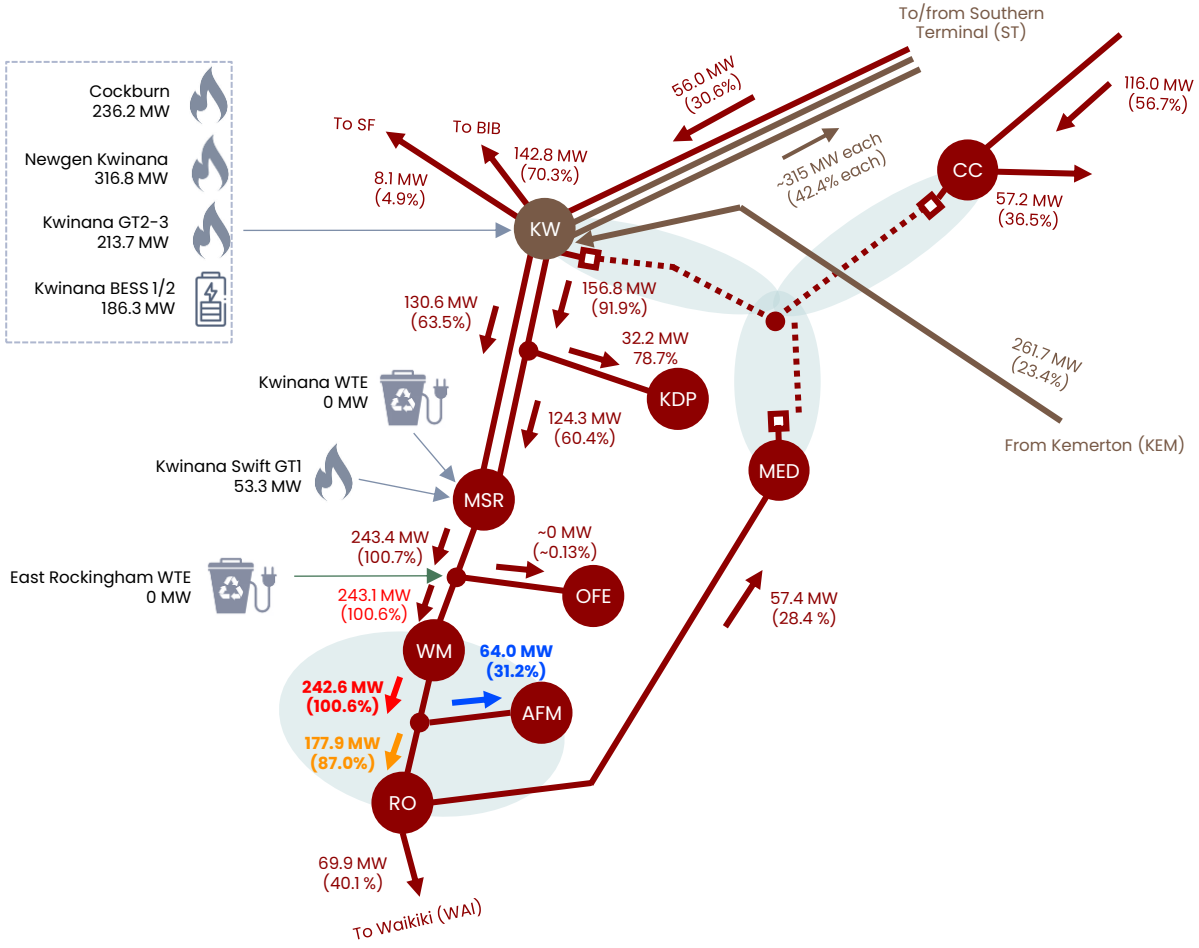
Constraint: NIL > {KW-CC-MED 81} [WM81-RWA (WM~)]

Overload of WM-AFM/RO 81 line on trip of KW-CC/MED 81 line

Indicative power flow simulation for 20/01/2025 19:00



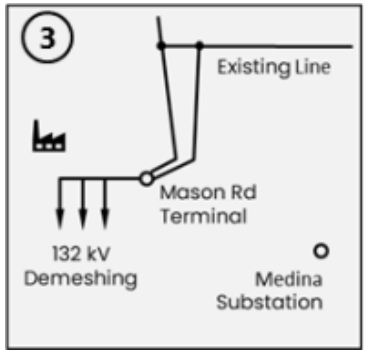
Power flow under intact condition

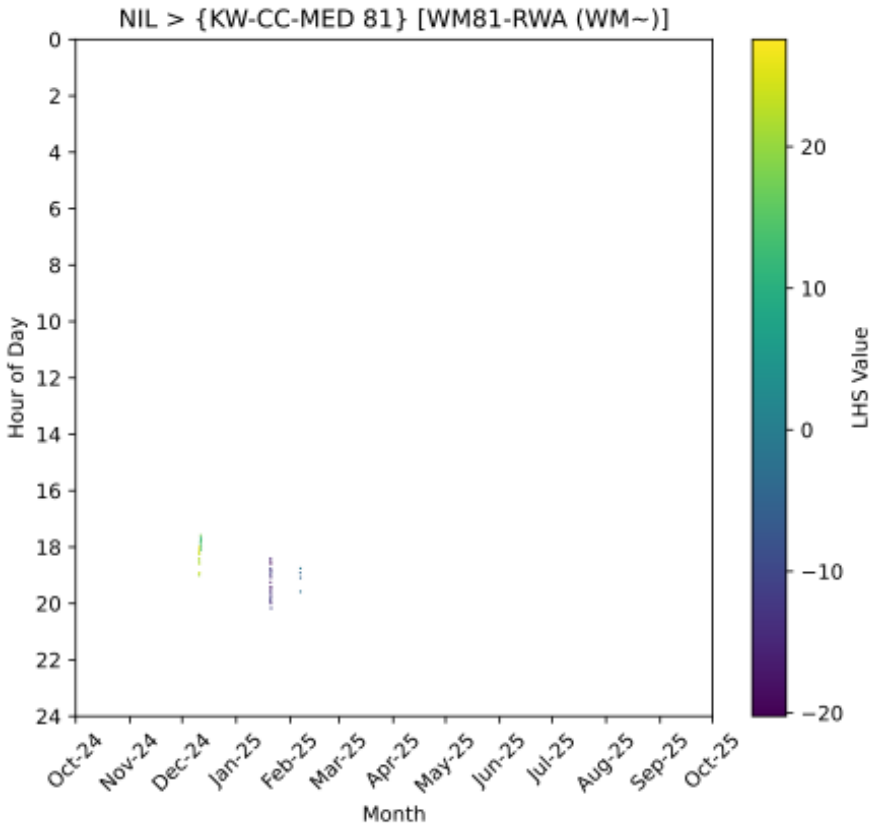


Power flow under N-1 condition

Constraint: NIL > {KW-CC-MED 81} [WM81-RWA (WM~)]

- This constraint deals with the **overload of the WM-AFM/RO lines** on the **trip of KW-CC/MED 81** (all 132 kV lines).
- This constraint binds rarely (0.04% of all intervals) during periods of high system load where **generation is high** in the 132 kV network around **Kwinana Terminal** and **Mason Road Substation**.
- These constraints are likely to bind more often in future as additional generators are connected in this area, e.g. East Rockingham Waste-to-Energy and AGL Kwinana K2 facilities.
- The WA Government's SWIS Transmission Plan and Western Power Transmission System Plan both include the **Clean Energy Link Kwinana Strengthening** project planned for 2030 (Stage 1) and 2033 (Stage 2), which is expected to de-bottleneck the 132 kV network and alleviate these constraints.





Key takeaways

- At present, the SWIS is relatively uncongested (most binding System Normal constraint occurs <3% of the time), but there are areas of the network where new entry of additional generation can create more frequent congestion.
- Network congestion tends to be seasonal (mainly in Summer, due in part to the more onerous Summer ratings) and is becoming increasingly weather dependent (e.g. more congestion when the wind is blowing).
- In meshed networks, binding constraints can also materialise in ways that are quite unintuitive, e.g. the trip of the TST-TS 81 line can overload the PJR-RGN 81 line over 200 km away.
- Network augmentations can help remediate bottlenecks—some projects like the Clean Energy Link – North project will assist in helping establish greater throughput in certain areas of the SWIS.
- Non-network innovations like the use of dynamic line ratings (which Western Power and AEMO are currently in the process of implementing) can also increase network capacity without having to build anything.

Thank you!

Please feel free to reach out for more information
contact@amperelabs.com.au

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