Transmission access reform model prototype – dashboard user guide

Introduction

This user guide has been prepared by the project team of the Energy Security Board (ESB) to inform interested stakeholders as part of the transmission access reform package. The user guide accompanies two Power BI dashboards.

Disclaimer

The ESB has provided you with access to the dashboards for the purpose of providing details for stakeholders regarding the impacts of the CRM and priority access. These dashboards present information from the following models:

- The full NEM CRM prototype, and
- The 7 node 2 region 1 FCAS model.

References to the dashboards below refer collectively to:

- The dashboard created to visualise the outputs of the full NEM CRM prototype, and
- The dashboard created to visualise the outputs of the 7 node 2 region 1 FCAS model.

Stakeholders are not permitted to commercialise the dashboards or any information contained in them.

While the ESB has endeavoured to ensure the content of the dashboards is accurate, adequate or complete, it does not represent or warrant its accuracy, adequacy or completeness. The ESB does not warrant or represent that the information in these dashboards is accurate, reliable, complete or current. To the extent permitted by law, the ESB and its advisers, consultants and other contributors to the models and the dashboards (or their respective associated companies, businesses, partners, directors, officers or employees) will not be liable for any errors, omissions, defects or misrepresentations in the information contained in the dashboards, or for any loss or damage suffered by persons who use or rely on the dashboards (including by reason of negligence, negligent misstatement or otherwise).

Background

The ESB is developing a transmission access reform package to address market design issues in response to congestion in the National Electricity Market (NEM).

On 24 February 2023, the Ministers requested the ESB to work with Senior Officials and stakeholders to develop the voluntary congestion relief market (CRM) and the priority access model.

The ESB released a TAR consultation paper. Submissions closed 26 May 2023.

Given the complexity of the reform and stakeholder feedback, the ESB recognises the need to establish an education workstream to familiarise stakeholders with the proposed changes. This includes presenting technical information in an accessible way.

The ESB has previously published worked examples of the model design based on a simplified intra-regional looped flow network limited to 4-5 nodes. Stakeholders have specifically requested real-world examples.

Education initiative

On behalf of the ESB, AEMO has developed a prototype to develop and test the detailed design of the model using the NEM dispatch engine (NEMDE). The objectives of the prototype are to:

- Test the validity of the model design – does it work on a NEM-wide scale?
- Inform design decisions
- Determine the impact on NEMDE for implementation cost purposes.

The ESB has developed a handful of scenarios to highlight key messages for stakeholders at this stage of the design process. Two scenarios were previously shared in Appendix E of the TAR consultation paper. A Power BI dashboard has been created to visualise these as well as new scenarios generated by the prototype.

This user guide confirms the methodology, source of data inputs and assumptions and explains the key information for each tab of the dashboard. It is structured to include information regarding:

- Development of the prototype
- Full NEM model
- 7-node model.

If there are any issues with the dashboards, please contact info@esb.org.au.

Development of the prototype

NEMDE is a scalable solver so the prototype has been developed in stages. The ESB has created two dashboards to communicate the key findings from two of these prototypes:

- 7 Node 2 region 1 FCAS service model (scenarios include priority access and the CRM)
- Full NEM based on historic dispatch intervals model (scenarios include the CRM).

Where does the data come from?

The 7-node model is a fictional network topology including an interconnector between two regions (nominated as Qld and NSW for illustration only). Data inputs are hypothetical assumptions.

The full NEM model uses historic dispatch intervals for the run scenarios. The data for the historic dispatch intervals is provided by AEMO and is publicly available through AEMO's market management system (MMS) database. The historic dispatch intervals provide a reference for energy requirements and energy market (EN) bids.

The full NEM model also contains assumptions made by ESB staff regarding costs and CRM bids including for each generator:

- Short run marginal cost (SRMC): This information is assumed by the ESB and has no connection to any specific or commercially sensitive information. It is used for the purpose of setting bidding strategies and calculating profitability of various generators in the CRM. A generator's SRMC includes opportunity costs. A negative SRMC means the generator effectively has negative costs to operate e.g. due to the combination of zero fuel costs and contract positions.
- CRM bids: The ESB has assumed bids for participants in the CRM. These bids are generally either set at or close to the SRMC of the generators or copied over from the energy bids.

Full NEM Model

General tips

The dashboard has different tabs to provide a storyboard of information.

Each tab has a panel showing the scenarios available for viewing. Users can navigate and select their choice of scenario. The tabs are linked so they will all update based on this selection.

The different tabs can be used together to provide a more complete picture of the outcomes.

Attachment Ai provides an image snapshot for each tab for the user's reference. Note that these images are static and shared for the user's orientation only. Users should refer to the live scenarios in the Power BI dashboard.

Overview tab

The overview tab shows key contextual information. It presents real outcomes from the historical dispatch interval in the energy market.

This includes:

- A description of the historic dispatch interval and scenario run in the prototype.
- Summary of key learnings for users to be alert to as they work through the dashboard.
- An overview of the constraints specific to the scenario. A chart shows the name of the constraint on the y-axis, and a count of the DUIDs (dispatchable unit identifier i.e. individual generating units) participating in the constraint on the x-axis.
- A stylised map of the NEM regions showing for that 5-minute interval:
    - RRP in each region
    - Direction and magnitude of interconnector flows between the regions.

Congestion tab

The congestion tab provides detail for the constraints examined in the scenario.

It presents real outcomes for the energy market from the historical dispatch interval, and simulated outcomes for the CRM.

This includes:

- A selector to choose which constraint to look at. In some scenarios, there may be more than one constraint that is of interest.
- A constraint description consistent with AEMO's 2022 Constraint Report (link).
- Information showing the relevant DUIDs that participated in the constraint in the energy market, and the constraint coefficient of each DUID.
- A map showing the location of the DUIDs that participated in the relevant constraint in the energy market. Red DUIDs participated in the constraints, blue DUIDs did not.
- A chart showing the dispatch information of each DUID participating in the constraint, including:
    - The DUID's dispatch in the energy market, i.e. status quo based on real outcomes from the historical dispatch.
    - The DUID's maximum availability, i.e. how much capacity is available for dispatch. Note that if a DUID's maximum availability is larger than its dispatched MW, it is either:
        - Constrained off, or
        - Bidding some of its capacity in a higher price band and, therefore, not being dispatched.
    - The DUID's CRM adjusted dispatch i.e.how much the dispatch has increased or decreased due to the simulated dispatch for the CRM.

Generator bids tab

The generator bids tab provides information on generator bids into the EN dispatch and the CRM. This tab contains the following information:

- A selector to visualize the nominated generator's results.
- The selected generator's bids in the EN dispatch. These bids have been taken from the historical bids into the NEM. The chart displays the bid quantity (MW) in each bid band ($).
    - If the bid is displayed as a line, this means the generator has bid a quantity equal with the length of the line into that particular bid band.
    - If the bid is displayed as a dot, this means the generator has not bid any capacity into this bid band.
- The selected generator's bids in the CRM dispatch. These bids have been assumed by the ESB. The information is displayed in the same way as the EN dispatch bids.

Regional CRM impact tab

The regional CRM impact tab shows the impact of the CRM dispatch on interconnector flows. It also shows the total profit obtained due to the CRM dispatch.

The impact on interconnector flows is shown in the stylised map on the left of the tab. This map is similar to the map on the overview tab, with the addition of the green/red numbers below the interconnector flow figures. These numbers show the change in interconnector flows in the CRM dispatch compared to the EN dispatch.

Note that in some cases, there are no changes in interconnector flows because the scenario is limited to intra-regional constraints with no inter-regional flows.

The total profit due to the CRM dispatch is a measure of the additional profits gained from running the CRM in that 5-minute interval.

Settlement details tab

The settlement details tab provides a full breakdown of the settlements including the CRM revenues and costs. Where relevant, column headers have an information box (i) to confirm the formula applied (Ctrl+Click).

The table sets out by DUID:

- SRMC
- Dispatch MW, revenues, costs and profits in the EN including FCAS
- Dispatch adjustment MW, revenues, costs and profits in the CRM including FCAS adjustments.

Cost calculations are based on the DUID's assumed SRMC which are hypothetical assumptions made by the ESB.

Users can identify the DUIDs most affected by participating in the CRM, by sorting the table from highest profit to lowest profit.

DUID CRM impact tab

The DUID CRM impact tab provides information on the specific impacts on individual DUIDs from participating in the CRM. This information includes:

- A selector that allows the user to look at particular DUIDs.
- A map showing the location of the affected DUIDs, including whether the DUID makes a positive or a negative profit.
- Waterfall charts showing the dispatch outcomes for energy and FCAS in the EN and CRM run.
    - The first column shows the energy/FCAS dispatch outcome in the EN run.
    - The second column shows the incremental dispatch outcome for energy/FCAS in the CRM run (i.e. whether the DUID is supplying more/less energy/FCAS).
    - The final column shows the total dispatch result from the combination of the EN and CRM run.
- The circular graphs show the incremental profit and revenue gained from participating in the CRM, relative to the energy dispatch.

Information in this tab is consistent with the 'settlement details' tab, but it is visualized in charts rather than tabulated. When users are deciding which DUID they want to investigate, it is useful to cross check to the 'settlement details' tab to identify the DUID of interest.

Users are reminded that profit calculations are based on assumed costs which are hypothetical assumptions made by the ESB.

7-node model

The 7-node model focuses on the impacts of introducing priority access and its interaction with the energy market and CRM trading opportunities.

- The priority level would be a new factor introduced into the energy market.
- The priority level does not affect the CRM.
- The priority level could be 'harder' or 'softer' which would determine whether prioritisation is more or less of a deciding factor in calculating dispatch outcomes.
- There is a spectrum of hardness/softness. At either end:
    - Absolutely soft (no priority) represents the status quo where dispatch relies on constraint coefficients.
    - Absolutely hard means the higher priority generator will be dispatched in preference to the lower priority generator in *all* circumstances. This can result in a dispatch that is not technically feasible.

The 7-node model helps to compare three scenarios which are described as:

- No priority i.e. absolutely soft or status quo
- Softer priority
- Harder priority

The prototype assumes a technical solution based on adjusted market floor prices (MFP). MFP adjustments would apply a different market floor price to different priority levels. A harder level of priority has a wider separation of adjusted MFPs.[1]

Attachment Aii provides an image snapshot for each tab for the user's reference.

Priority access overview tab

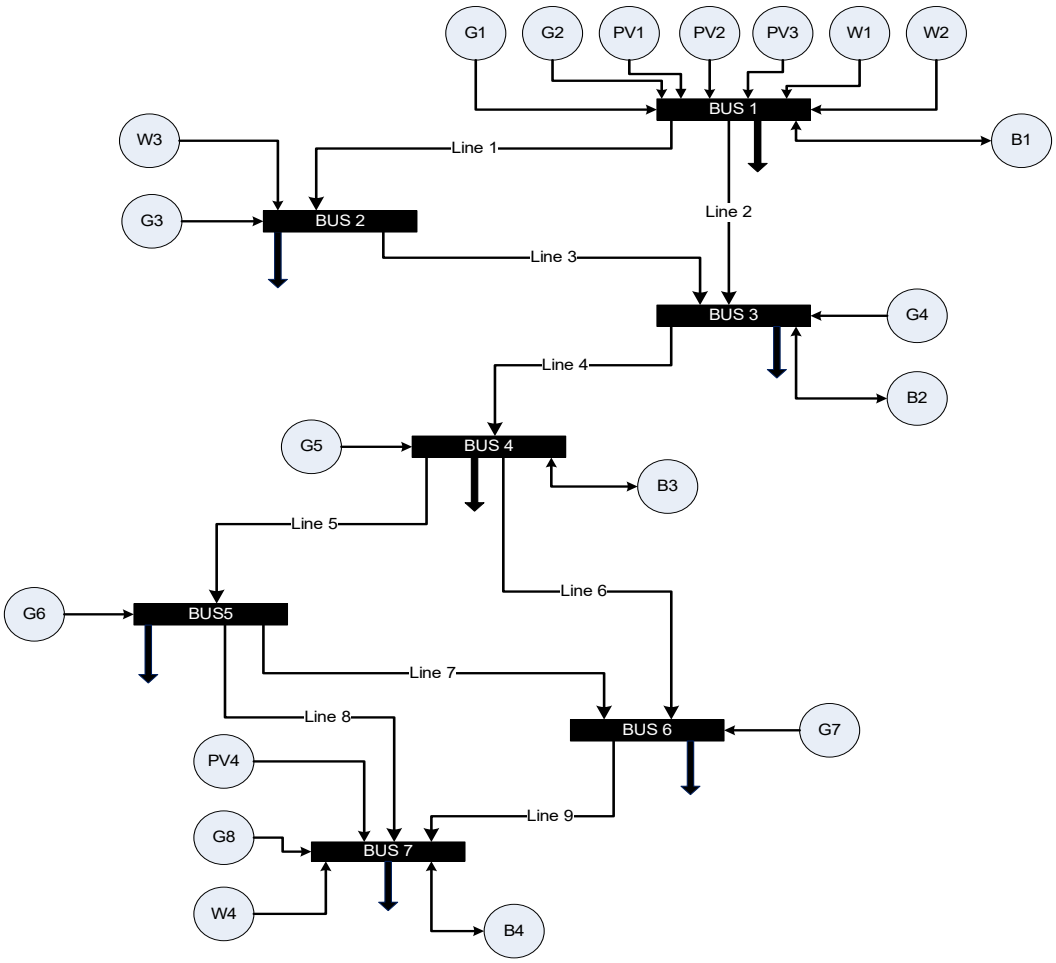
This tab shows a stylised network diagram assuming there are two regions with an interconnector, as well as key information about the scenario.

- The CRM price for each node is shown in the grey box.
- The generators connected at each node are attached to the grey box and are colour-coded to show their level of priority.
- The line flows are shown by the arrows between the nodes. There are two values; flows from the EN dispatch (in grey) and adjustments from the CRM dispatch (in green/red depending on the direction of change). More information is provided in the information box in the legend.
- The energy RRP for each of the two regions.

A more detailed figure of the network topology is shared below for reference. Bus 1-3 are located in one region, Bus 4-7 are located in a second region. The interconnector is represented by Line 4, connecting Bus 3 and Bus 4.

[1] Refer to section 3.3.1 of the TAR consultation paper for details.

Figure 1 7-node network topology



Priority access assumptions tab

This tab presents information about how generators are bidding in dispatch (similar to the full NEM model). It also shows the priority levels by generator.

- The MFP chart shows the adjusted range of market floor prices that generators can bid at in the energy market based on their priority level.
- Generators in priority 1 can bid at lower MFPs in the energy market than other generators.
- The adjusted MFP chart does not apply to the CRM where the MFP remains -$1000 for all generators irrespective of priority level.

Users can switch between scenarios 'no priority' 'soft priority' and 'hard priority' to see the change in adjusted MFPs for the energy market.

Generator settlements tab

The settlement details tab provides a full breakdown of the settlements. This includes:

- Priority level
- SRMC
- Dispatch MW, revenues, costs and profits in the EN dispatch
- Dispatch MW, revenues, costs and profits in the CRM dispatch.

Cost calculations are based on the DUID's assumed SRMC. As previously stated, a generator's SRMC includes its opportunity cost. A generator with a negative SRMC effectively has negative costs to operate e.g. due to the combination of zero fuel costs and contract positions. Some of the generators in the model have negative costs. This should be kept in mind when looking at profit outcomes, given the calculation involves these negative costs for some generators.

Where relevant, column headers have an information box (i) to confirm the formula applied (Ctrl+Click).

The bold numbers at the bottom of the table are the total for that column.

Regional Impacts tab

The regional impacts tab shows the outcomes of the model at a regional level across the different priority scenarios.

On the left-hand side of the tab, there are tables showing the regional settlement outcomes from dispatch for load. This includes the inter-regional settlement residue in each scenario.

On the right-hand side of the tab, there are charts showing the following information:

- Generator capacity by priority level. It is important to note that priority one is relatively large compared to other groups.
- Change in EN dispatch across the three scenarios. The chart shows that although the allocation of MW between priority bands changes in each scenario, the total MW dispatched does not change.
- Change in EN + CRM net dispatch across the three scenarios. This chart shows that assuming there is full participation in the CRM, the final physical dispatch does not change in each scenario i.e. the CRM achieves operational efficiency irrespective of the prioritization applied in the EN dispatch.

Priority access outcomes tab

The priority access outcomes tab shows the impact of the different priority levels on a single generator. The information in this tab includes:

- A selector to select which DUID to examine.
- Information on the particular DUID being examined, including the region, the node at which it is located, and its priority access level.
- A graph showing the EN and CRM dispatch outcomes for that generator across the priority levels. The total dispatch (EN + CRM) is shown by the orange dot.
- A table setting out some of the key figures associated with that generator across the three scenarios.

Priority access impacts tab

The priority access impacts tab shows the change in average profit outcomes between the priority levels in the three scenarios. The three graphs show the average profit for a generator in each priority band in the EN and CRM dispatch across the three scenarios.

Key insights include:

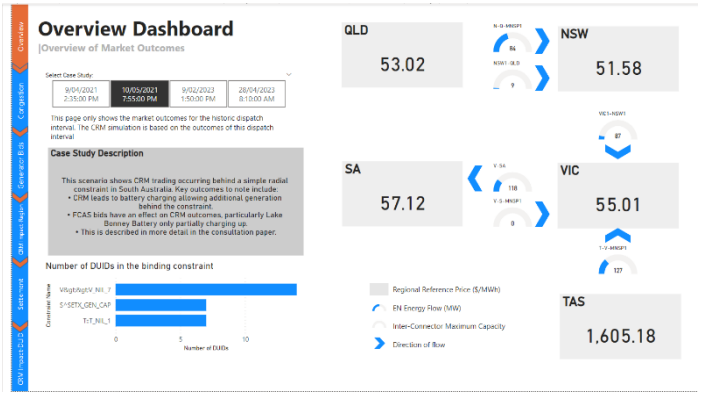
- Priority access leads to improvements in profitability for priority '1' generators relative to no priority.
- Location matters. Lower priority generators at less crowded areas of the network (e.g. node 4) have better outcomes in terms of profit than lower priority generators at crowded areas of the network (e.g. node 1 priority 2+).
- In this simplified example, there is a very small difference in terms of dispatch and profit outcomes between the soft and hard priority scenarios.

Detailed notes to accompany specific priority categories:

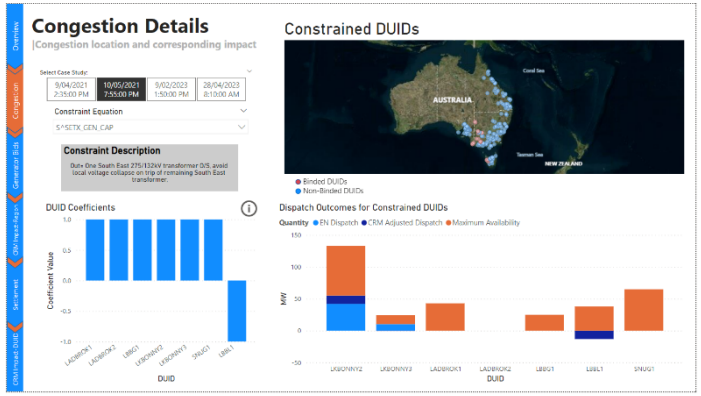
- Priority 1
    - Soft priority increases the EN dispatch for priority 1 generators relative to lower priority generators in the same area of the network. A good example relates to generators PV1 and G1 receiving priority access over generators PV2 and PV3.
    - Hard priority achieves a smaller incremental increase in EN dispatch, compared to soft priority. G1 receives slightly improved outcomes in terms of profit relative to the soft priority scenario.
- Priority 2
    - Soft priority reduces the EN dispatch for some priority 2 generators relative to priority 1 generators in the same area of the network. A good example is reduced access for generator PV2 in the EN dispatch. However, this generator participates in the CRM and increases its CRM adjustments relative to the 'no priority' scenario.
    - Hard priority sees further small decreases in overall profitability for priority 2 generators.
- Priority 3
    - Soft priority reduces the EN dispatch for some priority 3 generators relative to higher priority (Priority 1 or 2) generators in the same area of the network. A good example is reduced access for generator PV3 in the EN dispatch. However, this generator participates in the CRM and increases its CRM adjustments relative to the 'no priority' scenario.
    - Hard priority does not change the dispatch or profit outcomes relative to the soft priority scenario.
- Priority 4
    - There is no change from priority access that affects generators with priority level 4.
- Priority 5
    - There is no change from priority access that affects generators with priority level 5.
- Priority 6 – 7
    - Generators assigned Priority 6 and 7 have a lower priority level than Priority 5 but are still dispatched in the EN run.
    - This is due to the location of the generators in these bands.
    - For example, W4 has a lower priority (6) but is still dispatched in the soft and hard priority scenarios due to its location in a less crowded part of the network.
- Priority 8
    - There is no change in priority access that affects generators with priority level 8.

Attachment A.i Snapshots of the Power BI dashboard visualisation – full NEM model

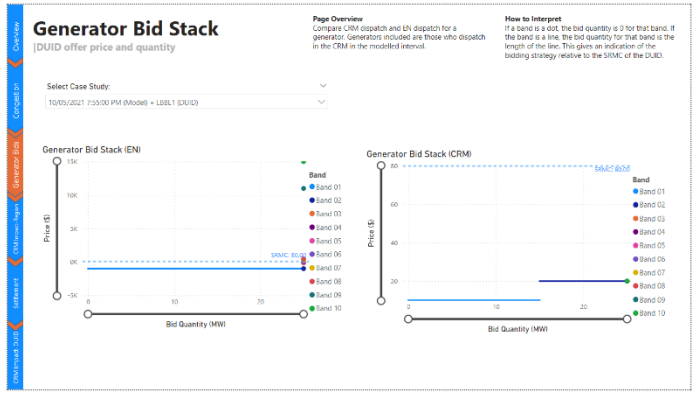
Tab: Overview



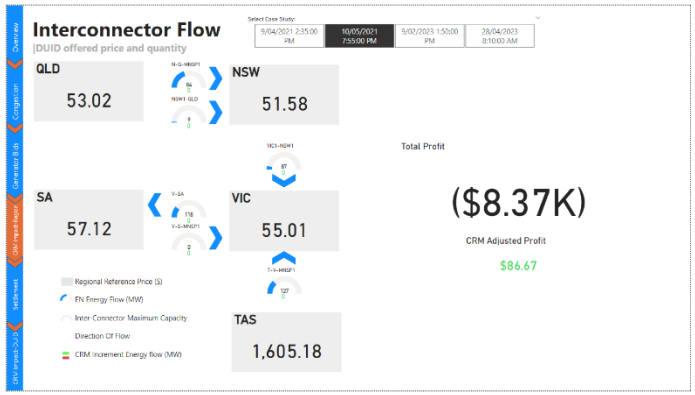
Tab: Congestion



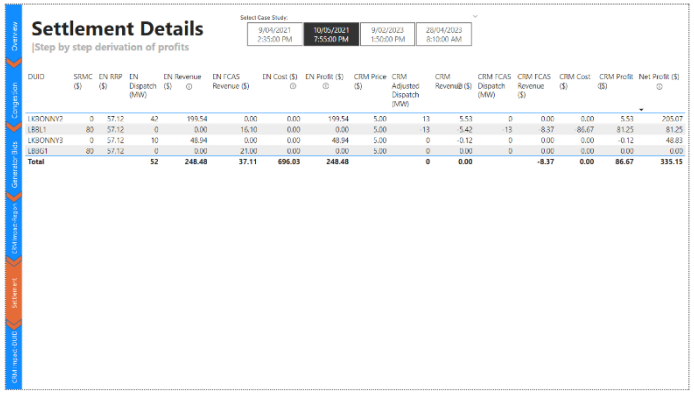
Tab: Generator bids



Tab: Regional CRM impact



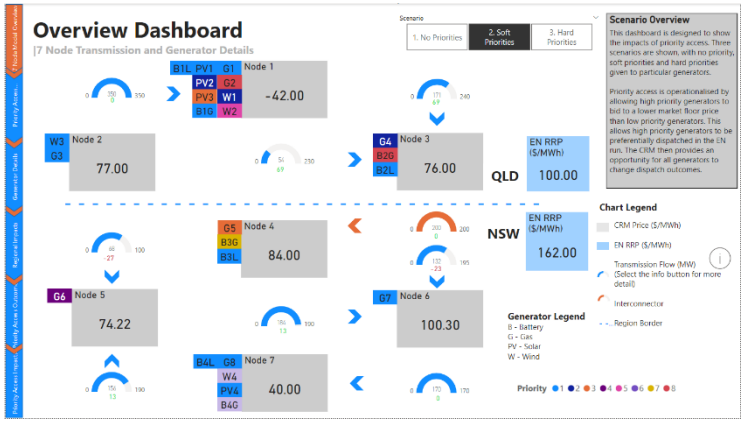
Tab: Settlement details



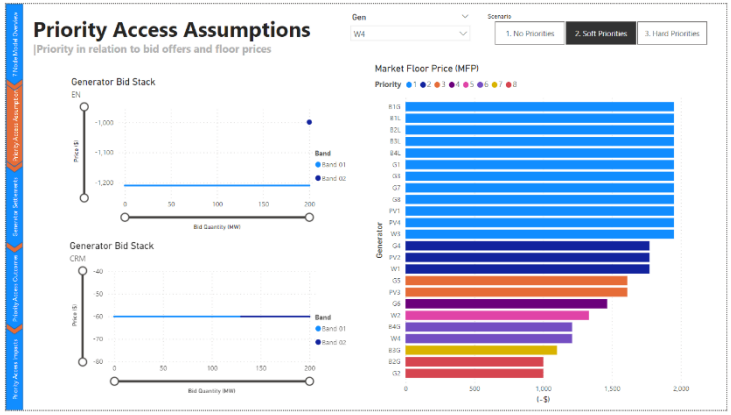
Tab: DUID CRM impact

Attachment A.ii Snapshots of the Power BI dashboard visualisation – 7 node model

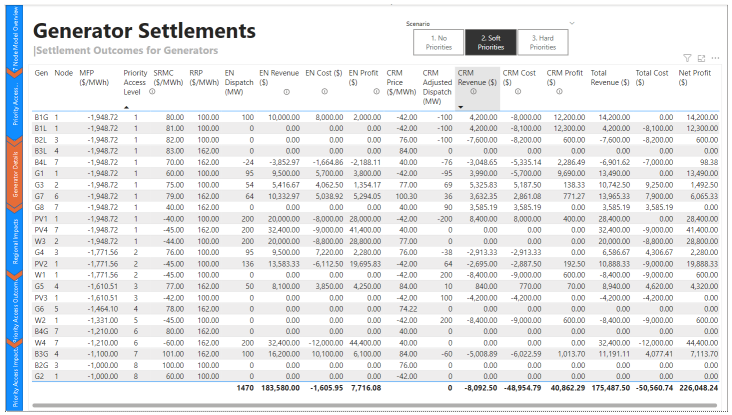
Tab: Priority access overview



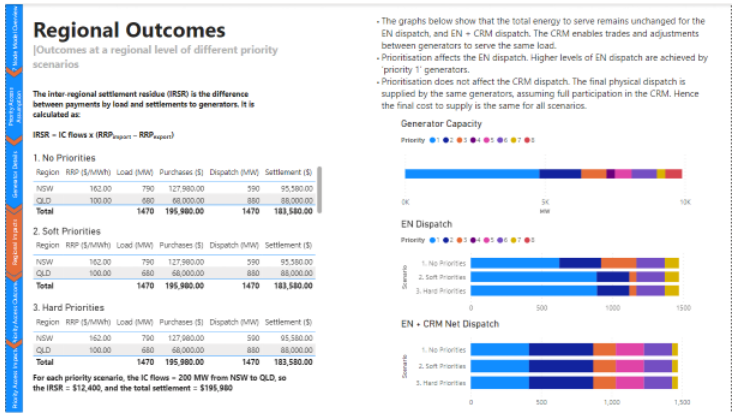
Tab: Congestion



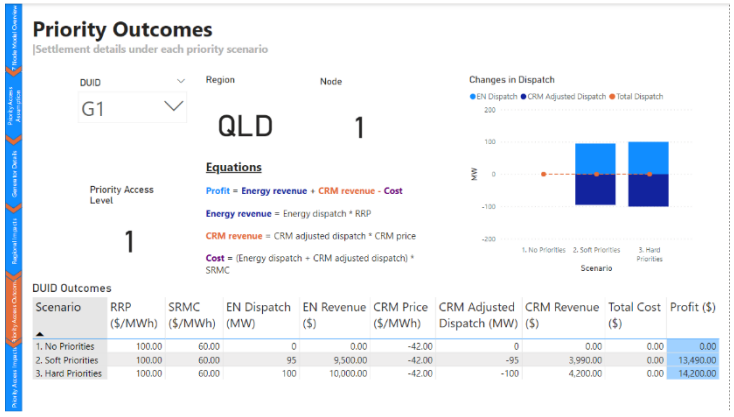
Tab: Generator settlements



Tab: Regional outcomes



Tab: Priority access outcomes



Tab: Priority access impacts