Review of NEM load relief

June 2023

Fact Sheet

Since 2020, AEMO has assumed a load relief value of 0.5% for the mainland National Electricity Market (NEM). AEMO's recent 'bottom-up' analysis of load composition confirmed that a load relief value of 0.5% remains appropriate at this stage for the mainland NEM.

Background

The amount of Contingency frequency control ancillary services (FCAS) procured is equal to the size of the largest credible contingency minus assumed load relief. Load relief is an assumed change in load that occurs when power system frequency changes. It relates to how particular types of load (such as traditional motors, pumps, and fans which use induction machines) draw less power when frequency is low, and more power when frequency is high.

As load is becoming less dependent on frequency (for instance, motor load is increasingly connected via variable speed drives that decouple the speed of the motor from system frequency), load relief has been declining.

In 2019, AEMO assessed the amount of load relief observed in historical events by comparison with a simulation model, and found that, based on these historical events, load relief varied based on time of day and connection point, averaging at around 0.5%[1].

AEMO has since conducted further analysis to estimate the composition of load in the NEM, applying a "bottom-up" approach, and accounting for the continuing evolution in load composition as customers move towards increasing use of power electronics devices and variable speed drives.

Development of a Composite Load Model (CMLD)

AEMO has developed improved dynamic power system models to represent the behaviour of NEM load during power system disturbances[2].

These models are based on industry best practice application of the "Composite Load Model" (CMLD), which features six load type components representing various kinds of motors (Motor A, B, C and D), power electronic load, and static load. Some of these load components have an inherent response to changes in power system frequency, based on the model parameters applied to each load component.

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[1] AEMO (November 2019) Review of NEM load relief, https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/load-relief/update-on-contingency-fcas-nov-2019.pdf.

[2] AEMO (November 2022) PSS®E models for load and distributed PV in the NEM, Section 3, https://aemo.com.au/-/media/files/initiatives/der/2022/psse-models-for-load-and-distributed-pv-in-the-nem.pdf?la=en.

Estimating load composition

To apply this model to the NEM, AEMO conducted a significant exercise to develop a “bottom-up” estimate of the composition of NEM load, and how this varies as a function of time of day, season, and other factors. This estimate was based on a range of data sources, including:

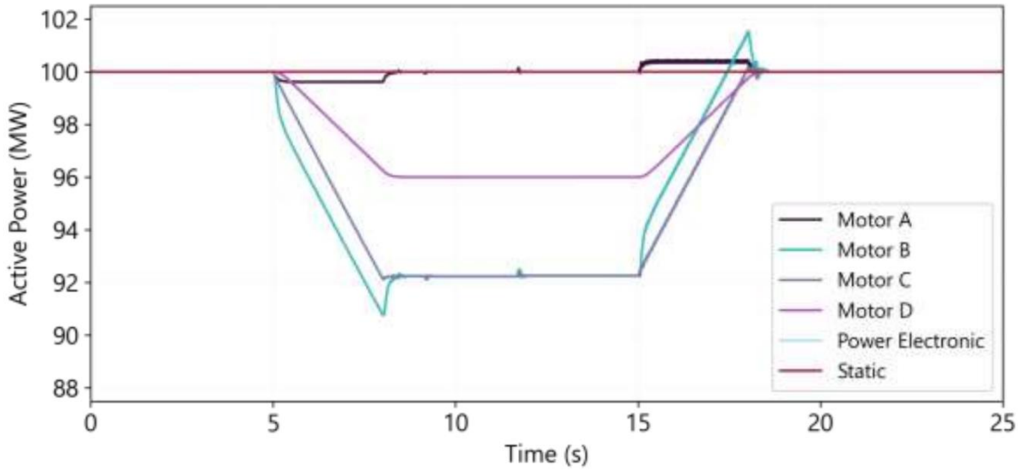
- The datasets for the AEMO *Electricity Statement of Opportunities* (providing an estimate of the proportion of NEM load that is industrial, residential and commercial),
- The Australian Government Residential Baseline Study (providing a detailed estimate of the composition of residential load),
- International literature reviews (applying “Rules of Association” to estimate the proportion of various industrial loads allocated to each CMLD load type), and
- AEMO datasets on the ~100 largest industrial customers in the NEM.

AEMO also engaged several consultants to provide further assessment of the composition of load categories for which inadequate data was available, such as commercial load[3], and “Motor D” type load[4] (representing single phase air-conditioning and refrigeration). These data sources were combined to result in an estimate of the proportion of load in each CMLD load type category, in each period.

Response to changes in frequency

The six load types in the CMLD model react differently to frequency disturbances, as illustrated in Figure 1, which shows the response of the different load types in the CMLD model in response to a frequency ramp to 48 hertz (Hz) then back to 50 Hz.

Figure 1 - Load model response to frequency disturbance



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[3] Delta Q (April 2020) AEMO Commercial Load Model, https://aemo.com.au/-/media/files/initiatives/der/2020/2020-06-26-deltaq-final-report-aemo-commercial-load-model-user-guide-revb.pdf?la=en.

[4] Energy Efficient Strategies (July 2020) Single Phase Induction Motor Loads on the NEM from Refrigeration and Air Conditioners, https://aemo.com.au/-/media/files/initiatives/der/2020/2020-08-05-ees-ac-load-composition.pdf?la=en.

The Motor B, Motor C and Motor D loads all demonstrate a degree of load relief. For Motor B and C, the torque of these motors is proportional to speed squared (load torque decreases as frequency drops). Motor B has a more aggressive response than Motor C as it has a higher inertia constant. Motor D represent single-phase compressor motors, and the load response is proportional to the frequency response, as the load torque varies linearly with speed.

Motor A represents constant torque loads, so there is no variation in torque with a change in frequency. Hence, the Motor A load only exhibits a slight change during the transient periods of the frequency ramp but settles at the pre-disturbance level when the ramp flattens.

Both the power electronic load and static load components exhibit no frequency dependency in the CMLD model and are only voltage dependent.

Each load component contributes to load relief, as shown in Table 1. A higher proportion of load associated with the Motor B and Motor C components will lead to a higher load relief across the NEM, while a higher proportion of load associated with power electronic and static load will lead to a lower load relief estimate.

Table 1 - Load relief associated with each load component

CMLD load component	**Load type represented**	**Typical applications**	**Load relief** (change in active power consumption / change in frequency)
Motor A	3P induction motors with high locked-rotor torque, low inertia (H = 0.1 s) and driving constant torque loads.	Common in commercial/industrial air conditioning compressors and refrigeration systems	0%
Motor B	3P induction motors with high inertia (H = 0.25 to 1.0 s) driving loads whose torque is proportional to speed squared.	Common in commercial ventilation fans and air-handling systems.	2%
Motor C	3P induction motors with low inertia (H = 0.1 to 0.2 s) driving loads whose torque is proportional to speed squared.	Common in commercial water circulation pumps in central cooling systems.	2%
Motor D	A specially developed performance model intended to represent single-phase (1P) compressors of residential air-conditioning loads. A constant torque load characteristic and minimal inertia make these motors prone to stall.	This motor type more common in the United States of America, but is also found in some 1P residential and light commercial refrigerator compressor motors in Australia.	1%
Power Electronics	Consumer electronics (computers, televisions), appliances (dishwasher), office equipment, and variable frequency drives (VFDs) used in commercial and industrial settings.		0%
Static load	The remainder of the unclassified aggregate loads, including constant impedance loads such as incandescent lighting.		0%

Estimates of NEM load relief based on load composition

The load relief contribution from each CMLD load component can be combined with the “bottom-up” estimate of load composition in each interval to estimate the total load relief across each NEM region, in each period. The combined estimates of regional load relief, based on this bottom-up assessment, are summarised in Table 2.

Table 2 - Load relief estimated for each NEM region (bottom-up assessment)

	Load relief (change in active power consumption / change in frequency)	
NEM region	**Average**	**Range**
NSW	0.6%	0.6 – 0.7%
VIC	0.7%	0.6 – 0.8%
QLD	0.8%	0.7 – 0.9%
SA	0.6%	0.5 – 0.8%

Based on this analysis, load relief varies from period to period, and is estimated to be generally in the range of 0.6 - 0.8%. Allowing for uncertainty in these estimates, this is consistent with the present estimate of load relief applied in the NEM mainland of 0.5%.

The data showed a general trend towards reducing composition of load in the Motor B and Motor C categories over time (and increasing proportion of power electronics and variable speed drives), which will tend to further reduce load relief in the NEM mainland over time.

Next steps

Based on this assessment, AEMO will continue to apply a load relief value of 0.5%. AEMO will continue to monitor mainland load relief, and advise of further changes if required.

Tasmanian load relief will be reviewed separately. Tasmania has a different load composition than the mainland, and therefore applies a different methodology for determining FCAS requirements.

AEMO is also working with transmission network service providers (TNSPs) to continue to extend coverage of high speed monitoring to other parts of the NEM, both for event analysis and real-time monitoring. This will provide further data to support direct measurement and assessment of load relief at more locations in future.